Particle Size Analysis 1985

Edited by
P. J. Lloyd

Particle size analysis 1985

Proceedings of the
Fifth Particle Size Analysis Conference
University of Bradford, Yorkshire, UK
16–19th September 1985

Organised by the Analytical Division of
The Royal Society of Chemistry

Cosponsored by
German Institute of Chemical Engineers, (GUC),
West Germany
Group for the Advancement of Spectroscopic and
Physical-Chemical Methods of Analysis, (GAMS), France

Edited by

P J Lloyd
Department of Chemical Engineering
University of Technology,
Loughborough, Leicestershire, UK

A Wiley–Interscience Publication

JOHN WILEY & SONS
Chichester · New York · Brisbane · Toronto · Singapore

Library of Congress Cataloging in Publication Data:

Particle Size Analysis Conference (5th: 1985: University of Bradford)
Particle size analysis 1985.

'Cosponsored by Gerrman Institute of Chemical Engineers, (GUC), West Germany, Group for the Advancement of Spectroscopic and Physical-Chemical Methods of Analysis, (GAMS), France.'
'A Wiley–Interscience publication.'
Includes index.
1. Particle size determination—Congresses.
I. Lloyd, P. J. II. Royal Society of Chemistry (Great Britain). Analytical Division. III. German Institute of Chemical Engineers. IV. Groupement pour l'avancement des méthodes spectroscopiques et physico-chimiques d'analyse (France) V. Title.
TA418.8.P28 1987 620'.43'0287 86-24546
ISBN 0 471 90832 0

British Library Cataloguing in Publication Data:

Particle Size Analysis Conference (*5th: 1985: Bradford*)
Particle size analysis 1985
1. Particle size determination
I. Title II. Lloyd, P. J. III. Royal Society of Chemistry, *Analytical Division* IV. VDI-Gesellschaft Verfahrenstechnik und Chemieingenieurwesen
V. Group for the Advancement of Spectroscopic and Physical-Chemical Methods of Analysis
620'.43 TAA418.8

ISBN 0 471 90832 0

Printed in Great Britain

Particle size analysis 1985

ORGANISING COMMITTEE

Dr. T. A. Aden
Dr. L. P. Bayvel
Mr. G. Butters
Mr. R. Buxton
Mrs. R. Dowson*
Mr. J. E. C. Harris (Secretary-Treasurer)
Mr. R. W. Lines (Vice Chairman)
Mr. P. J. Lloyd
Dr. N. A. Orr
Mr. M. Rhodes*
Dr. A. Rood
Mr. A. van Santen
Mr. J. P. K. Seville
Dr. N. G. Stanley-Wood* (Chairman)
Mr. R. Wilkes*
Dr. R. Wilson

*Local Committee

FOREWORD

The study of particle characteristics in terms of size, surface area and shear has attracted widespread interest over many years. Initially the emphasis has been on the instrumentation and measurement of particle size but with the increasing importance of particle characterisation in the fields of chemical processing, metallurgy, pharmaceuticals, food and biological materials, the informational needs have been enlarged and the emphasis has changed to incorporate material parameters other than particle size.

The Particle Size Analysis Group, which is soon to be renamed the Particle Characterisation Group, of the Analytical Division of the Royal Society of Chemistry is pleased to present the formal Proceedings of the Fifth International Conference in Particle Characterisation PSA '85. These Proceedings contain 40 original papers together with 4 Plenary lectures from Drs. T. Allen, M. Martin, N. Stanley-Wood and Professor E. Heidenreich together with edited discussions on the scientific papers presented at the conference held at the University of Bradford in September 1985. This PSA Conference had for the first time simultaneous translation and satelite television coverage to communal and exhibition areas and attracted over 200 delegates. This number attending from 14 different countries including China,France, Germany (West and East), Scandinavia, Israel, Spain and USA, draws attention to the international nature of the subject of particle characterisation.

An addition to and an important part of the Conferencewas the exhibition where many instrument manufacturers demonstrated their increasing effort and ingenuity in the production of new, novel, rapid and automatic instrumentation for the measurement of particle characteristics.

The success of the conference is judged not only on the formal Proceedings in which the Group is appreciative of Mr. P.J. Lloyd in editing these Proceedings but also to the authors and delegates who contributed to the formal presentations and discussions and to the informal conversations which readily occurred at over good food and "beverages".

I should also like to give my thanks to the Chairmen of the Scientific Sessions for their efforts in achieving the smooth running of the Scientific Programme.

My sincere thanks and gratitude must also be expressed to the local committee for the tremendous effort they gave to this conference-Mrs. Ruth Dowson, Mr. Martin Rhodes - and especially Mr. Ray Wilkes who was responsible for a successful and well organised exhibition.

Lastly recognition and thanks must also be made and given to the Main Committee of the Particle Size Analysis Group who planned and hopefully will continue to plan such international conferences.

Dr. Nayland Stanley-Wood, Chairman of the Particle Size Analysis Group Analytical Division, Royal Society of Chemistry.

CONTENTS

PLENARY LECTURES

Particle Size Analysis 1985
Edited by P. J. Lloyd

Trends in Particle Characterisation

Dr. Nayland Stanley-Wood
Schools of Chemical Engineering & Powder Technology
University of Bradford
Bradford BD7 1DP
W. Yorkshire, England.

INTRODUCTION

When Kaye (1) finished his PSA81 Plenary Lecture, his vision of the future was to have a lecture entitled "Trends in the Characterisation of Fineparticle Systems". This provocative and innovative title was intended to promote a move forward, from the measurement of the size of individual irregularly shaped particles and their distribution functions into the more complicated task of evaluating the behaviour of particle systems. The two key words in that proposed title were "Characterisation" and "Systems".

In every industrial process which handles, moves, separates, mixes, compacts, dries or wets a collection of particles there is a need to know, especially when the system does not function as intended, either the physical, the physico-chemical or the chemical characteristics of the assembly of particles to comprehend and correct the system.

When dealing with powdered materials in terms of rheology, flowability, reactivity, bulk density and solubility, more than just the parameters of size and size distribution are therefore needed although many chemico-physical processes are influenced and governed by size and size distribution of solid materials.

The emphasis on size measurement and distribution has grown up because of the often carelessness with which the powder technologist and engineer have shown in using the term "particle size". The term "particle size" is meaningless by itself and has to be qualified in terms of technique and spatial dimensions because, for irregular shapes, various measurement techniques measure different physical sizes. Universal use of the German DIN 66141 Standard for size and frequency distribution notation by all powdered technologists would mitigate the confusion that arises as to whether the particle dimension is a number, length, surface, freefall, Stokes or volume diameter. Even within the same measurement technique such as microscopy there are different geometrical and statistical diameters which must always be adequately described.

The physical criteria available for the measurement of size and size distribution of irregular particles (Fig. 1) are tacitly assumed to be those physical criteria which will also be needed to characterise particulate systems. It is being shown however that some of the techniques used for laboratory off line size analyses are not applicable for instream characterisation of flowing particulate systems (2,3,4). When a solid is in contact with a fluid or solid phase the inter-relationship between the phases is dependent upon the surface area or surface energy of the phases. When movement is present between or over surfaces the inter-relationship between particle and particle is that of shear (5,6,7) and between particle and fluid is that of either rheological thixotropy or shear thickening (8).

The physical parameters needed to identify, measure and control multi-phasic systems now have to include the criteria of shape, surface and shear. Fortunately proven particle characterisation techniques such as image analysis, sedimentation, light attenuation and scattering and electro-sensing can also be applied to non solid states of matter and also to the inter-relationship between one, two or three phases. Harold Heywood - one of the founder members of Particle Technology - was fond of referring to powder systems as the fourth state of matter and the need to treat powder systems as a whole. This is becoming more and more applicable as the knowledge and techniques of characterisation of particulate systems advances.

PARTICLE CHARACTERISATION IN THE PAST 5 YEARS

It can be of benefit at times to review the number of scientific papers published and to compare the progress made in the fields of Powder Technology and Particle/Powder Characterisation with different scientific disciplines. In reviewing the scientific literature in the fields of chemistry, physics and engineering over the period 1980-1984 the number of scientific papers abstracted and reported in the periodicals "Chemistry Abstracts", "Physical Abstracts", and "Theoretical Chemical Engineering Abstracts" were counted and expressed as a percentage increase or decrease from a 1980 base. The emphasis on chemical research over this period (Fig. 2) seems to have declined whilst in the physical sciences there has been an increase. A similar increase can also be seen with articles abstracted from the scientific journals which have a powder technological content. The information on abstracted publications in the field of powder technology was obtained by a computer search using selected key words. This search was made possible by the facilities within the J.B. Priestly Library of the University of Bradford which has a modem link with Dialtech (9). The number of abstracts published each year in the periodicals "Chemical Abstracts", "Physical Abstracts" and "Chemical Engineering Abstracts" is of the order to 500,000. The total number of abstracts used in this 5 year survey being greater than 2½ million while for the powder technology data over 80,000 abstracts were found which contained keywords applicable to the

research and development field of particle/powder characterisation.

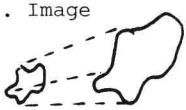
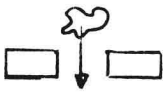
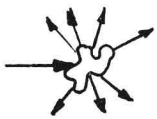
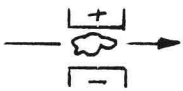
PHYSICAL CRITERIUM	DIAMETER MEASURED	SIZE RANGE APPLICABILITY MICROMETRE
1. Image 	Projected Area..d_a	Optical 0.8-800 Electron 0.002-15
2. Mechanical 	Sieve Diameter..d_t	Dry 40-1000 Wet 1-40
3. Dynamic 	Free Fall Diameter.....d_f Drag Diameter..d_d Stokes Diameter..d_{st}	Gravity 1-100 Centrifugal 0.05-25
4. Attenuation 	Projected Area..d_a Stokes Diameter..d_{st}	X-Ray 0.05-100 Centrifugal 0.05-50
5. Scattering 	Surface Volume Diameter.....d_{sv}	0.3-50
6. Electrical 	Volume Diameter..d_v	0.5-300
7. Surface 	Surface Diameter..d_s Surface Vol. Diameter.....d_{sv}	Permeametry 0.1-50 (mean) Adsorption 0.005-50 (mean)

Fig. 1 Physical criteria for the measurement of size

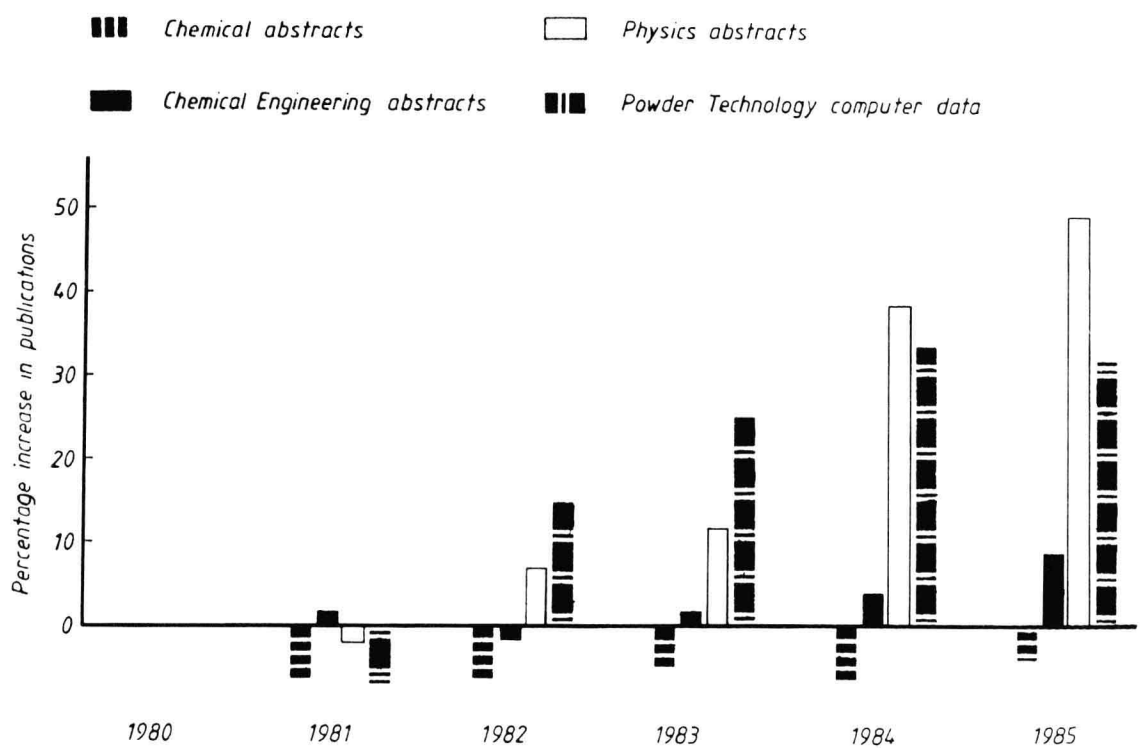


Fig 2 Trends of published papers in Physico-Chemical related subjects since 1980

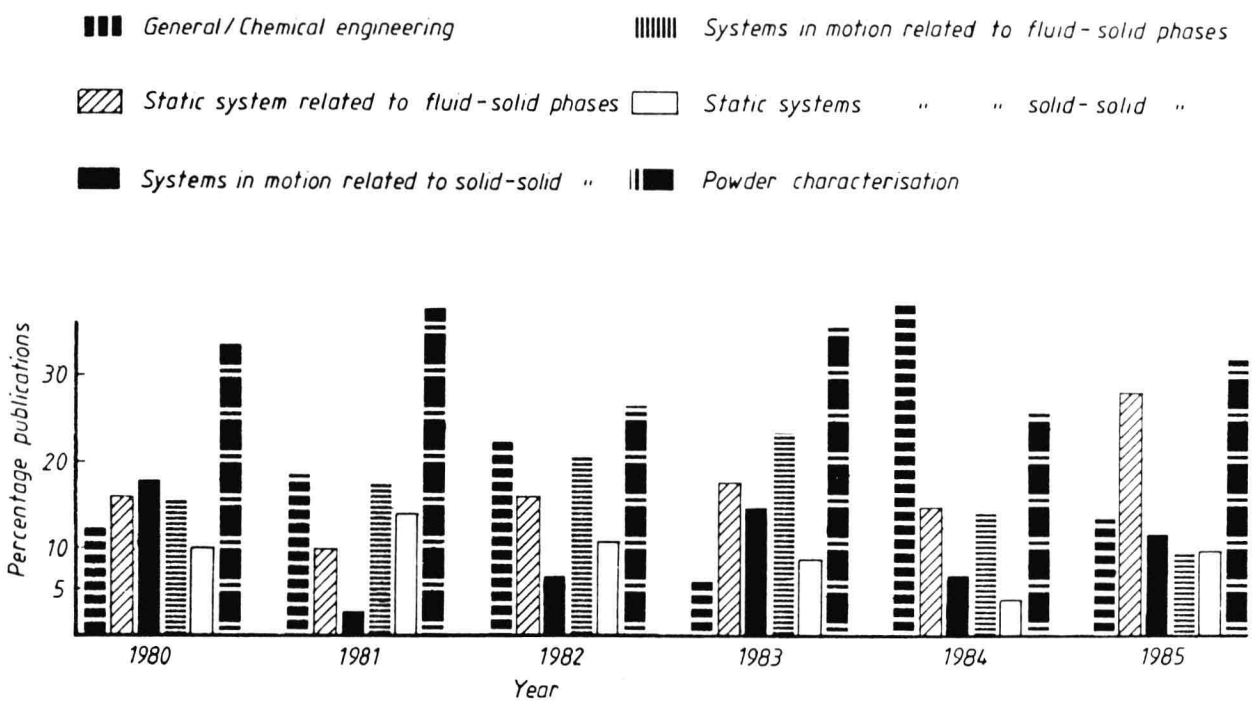


Fig 3 Trends in published work categorised by various powder/particle related systems