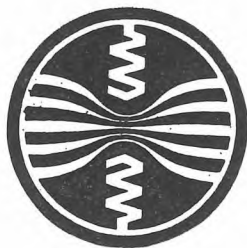


BULLETIN



BRITISH SOCIETY OF RHEOLOGY

1971, No. 1, Vol. 14

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Hon. Editor:

JOHN HARRIS,
Schools of Chemical Engineering,
The University,
Bradford,
Yorks. U.K.

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FOREWORD

As far as may be judged at the present time, it appears that there is a desire in some quarters to formalise rheological research in the United Kingdom beyond the present loose situation in which industrial laboratories, research associations, universities and government laboratories, exemplified by N.E.L. East Kilbride and the Warren Spring Laboratory, investigated the field of rheology in relation to "industrial problems." This investigation activity ranges from the routine test to the purely imaginative speculation.

Some of the motivation behind the simple desire arises from the case of tribology which besides having a similar name to our own field, also has overlapping physical interests. The apparently phenomenal acceleration of the subject of tribology relative to those travelling in rheology has left some with the impression that they have seen a speck on the horizon, it has accelerated and passed by like a fire engine and is now a speck on the opposite horizon. The feeling of the drivers is that they should call in at the nearest garage and get a couple of extra cylinders fitted. It is then a matter of human dignity not to be passed by, or at least not observed to be by-passed in this way.

At this stage the analogy has to be translated into terms of aristocracy which is a Platonic concept (Ariston and Kratos) of rule by the best. Out of the drivers are to be selected the leaders who by their aptitude and special training have shown themselves to be worthy of having all authority invested in them, and this was the specification of Plato. Thus, there is in the city-state of rheology the need for authoritative leaders in the form of official rheology centres, ramified by all the strong arguments of Plato for his leaders; the philosopher-kings.

This attractive political philosophy also has its objectors and alternatives which need examination, so that understanding of the problems involved in establishing official centres can be spread to those who have given the matter no thought, but will be affected and can be enhanced for those who have already given the matter some thought.

A NOMOGRAPH FOR USE WITH THE WEISSENBERG RHEOGONIOMETER AND THE FERRANTI-SHIRLEY VISCOMETER

by R. W. Higman

(Warren Spring Laboratory, Stevenage, Herts.)

At Warren Spring Laboratory a wide range of non-Newtonian materials are characterised using Weissenberg Rheogoniometers and a Ferranti-Shirley viscometer.

The comprehensive range of shear rate and shear stress measurement available on the rheogoniometer is covered by a number of torsion bars and cones of various diameters and angles. The choice of the correct components for testing an "unknown" fluid by trial and error is time-consuming, and involves frequent calculation using standard formulae although, from experience, a good guess can be made. To remove the guesswork and enable a rapid and accurate decision to be made, a nomograph has been prepared based on the following formulae:

$$\tau = \frac{3\Delta T K_T}{2\pi R^3}, \quad \gamma = \frac{(\text{R.P.M.})\pi}{30 \tan \alpha} \quad \text{and} \quad y = \frac{\tau}{\gamma}$$

where ΔT = deflection of torsion head (scale units)

K_T = torsion bar constant (Nm/scale unit)

R = cone radius (m)

R.P.M. = rotational speed of cone (rev/min)

α = cone angle (degrees)

τ = shear stress (N/m²)

γ = shear rate (s⁻¹)

y = apparent viscosity (Ns/m²)

Normally the approximate viscosity is known, or it can readily be found by performing a quick test using the cone and torsion bar as set up for a previous determination and left in the instrument. The choice of the correct cone angle for the required shear rate range is not extremely critical, owing to the wide range of the logarithmic gear box, but depends more on such factors as sample volume and particle size. The selection of the correct cone diameter and torsion bar for the shear stress range is more difficult because of the restricted range of torque measurement for each torsion bar.

To illustrate the use of the nomograph, the following example has been worked out. A fluid of approximate viscosity 700 Ns/m² is to be tested at shear rates between 10 and 100 s⁻¹. A cone of 1° angle is selected, and the required gear box settings are found to lie between 19 and 28 for 3,000 rpm synchronous motor unit fitted to an R18 model. Having decided the shear rate range, the shear stress range

is fixed between 5×10^3 N/m² and 5×10^4 N/m². Selecting a 50 mm diameter cone, it is found that to produce a reasonable deflection on the meter scale of, say, 100 thou, a torsion bar with a constant of $(10^{-2} \text{ Nm})/\text{thou}$ is required.

From the above, it may be seen that the nomograph may also be used in reverse, as a means of rapidly calculating an unknown viscosity, using known cones, torsion bars, scale readings and gear box settings, e.g. in the rapid determination of the approximate viscosity referred to above.

Most models, except the R17, are covered by the R18 and R15 motor unit marks given on the nomograph. Further marks are, however, easily fixed by drawing two intersecting lines for any two gear box settings for which the rotational speeds of the lower platen are known.

The procedure for use with the Ferranti-Shirley viscometer is similar to that for the rheogoniometer, except that the shear rate determination starts at the rotational speed scale and the deflection is equal to the "scale reading" times the meter deflection.

(Copies of the nomograph may be obtained from the Director, Warren Spring Laboratory, P.O. Box 20, Gunnels Wood Road, Stevenage, Herts. SG1 2BX for a charge of £1 (one pound)—cash with order please.)

THE PRESIDENT

PROFESSOR J. LAMB, D.Sc., Ph.D., M.I.E.E. F.Inst.P., F.R.S.E.

Dept. of Electronics and Electrical Engineering,

University of Glasgow

From 1943-46 he was a member of a research team under (then) Professor Willis Jackson in the Electrical Engineering Department at Manchester University. The research was under an extramural Contract with the Ministry of Supply and was concerned with the study of the behaviour of coaxial and wave-guide transmission systems at microwave frequencies and with associated investigations into properties of dielectrics. He developed a range of experimental techniques using cavity resonators for the measurement of dielectric properties at microwave frequencies and carried out the first measurements of the dielectric properties of ice in connection with problems of radar propagation through hail and snow showers.

From 1946-55 his research at Imperial College was concerned with the origin of the absorption of ultrasonic waves in liquids and later in solids. New experimental techniques were developed for the measurement of ultrasonic absorption and velocity of propagation

and special studies were made of ultrasonic relaxation in liquids arising from "fast" reactions. From 1955 onwards, he had been principally concerned with viscoelastic relaxation processes in lubricating oils, synthetic lubricants and polymer melts. Their Research Group, now in Glasgow, had developed techniques using cyclic shear stress operating at frequencies ranging from a few Hertz up to 1GHz and their work in recent years has led to a new phenomenological model which substantially accounts for the principal region of viscoelastic relaxation in non-polymeric liquids. For polymer melts we have combined this model with the well-known Rouse theory for polymer mode relaxation.

Other research in which he has been involved in Glasgow has been concerned with microwave acoustic interactions in bulk semiconductors, the development of thin film piezoelectric transducers, acoustoelectric amplification in piezoelectric semiconductors and, recently, the study of acoustic surface waves. This work has been aimed at device development and signal processing.

His predominant teaching interests have been in electrical materials, electrical theory and electromagnetism and some five or more years ago, we set up in Glasgow a comprehensive Electrical Materials Laboratory which, at that time, was regarded somewhat as an innovation in teaching and received wide publicity. It is now followed by many other University Departments of Electronics and Electrical Engineering.

REPORT ON THE CONVERSAZIONE ON PIPELINE DESIGN FOR NON-NEWTONIAN AND SOLID-LIQUID SYSTEMS

J. Harris

(Schools of Chemical Engineering, The University of Bradford,
Bradford 7, Yorkshire.)

(1) Introductory Remarks

At the present time there is no generally agreed approach to the problem of pipeline design for the transport of non-Newtonian and Solid-Liquid systems, even on the most pragmatic level. Yet this is one of the simplest flow situations in the field and the one with the longest and most intensive history of investigation, reaching back as it does to the time of Poiseuille.

The current signs are that pipeline transport of materials is going to become more prominent in the immediate future. In the petroleum industry this form of transport is already of considerable importance, in Civil Engineering the pumping of concrete over lengthy pipelines is becoming commonplace. The anti-pollution movement is almost certain to gain ground and encourage further reprocessing of waste

products and hence further pipeline transport of non-Newtonian and solid-liquid materials.

So it is quite apparent that in addition to the traditional chemical process industries with their products, there are others, which together will add up to present a formidable body of interests. Contrast this with the lack of generally agreed design and correlation methods and it is quite apparent that here is a timely problem and an area of technology in great need of rationalisation.

As an initial step a number of people who are active in this field were invited to join in a *conversazione* to discuss the problem and see how far it is possible to go in making proposals which will be helpful in unifying the field of pipeline transport and also in suggesting guidelines for designers.

(2) Objects

The objects behind the meeting were grouped under two main headings:—

(i) *To summarise the state of the art on the correlation of pipeline data and design schemes, including:*

- (a) The classifications of the field currently in use.
- (b) The basis of design work.
- (c) The effectiveness of the methods described in correlating data.
- (e) The extent to which the above methods have been experimentally verified.

(ii) *To establish trends for further work including:*

- (a) Pooling of data from past and future work for independent assessment.
- (b) Establishment of national facilities for experimental work.
- (c) Range and scale of experimental rigs required in the immediate future.
- (d) Areas requiring further experimental and/or theoretical treatment.

(3) Conclusions

(i) *State of the Art.*

A classification of important aspects of pipeline transport was prepared based on a division into the two main groups: substance and environment. One or two amendments were suggested and particular attention paid to the distinction between “fast” settling and “slow” settling, the general feeling was that these sub-classes are not solely properties of the substance, but also depend to some extent upon its environment. Any classification based upon forces acting on particles might be difficult to put into general use, classification did not appear possible at the present time.

Excluding strength calculations for pipework, surprisingly little could be said about the basis of design beyond "minimum transport conditions" for substances with a tendency to settle. Although the question has wide ramifications no formulations seemed possible other than the correlation and prediction of physical data, this aspect was in fact rapidly crystallised out and treated at some length.

Current practice is to treat the flow dilute nearly symmetrical particles on an entirely different basis to that used for non-Newtonian Solutions, slurries and emulsions. In the former the material is classed as Newtonian and correlations revolve around finding the controlling parameters of the friction factor difference.

C_f mixture - C_f water

(If air or some other continuous phase is used instead of water then C_f air etc. is used as appropriate.)

It was contended that data for these dilute systems correlation is observed on a basis of Froude number U^2m/gD where U_m is the mean velocity of the continuous phase g is the local gravitational acceleration and D the pipe diameter. The correlation methods were reported to be successful on the materials treated to date.

The solutions, slurries and other materials are often treated by the basis of Dodge-Metzner generalised Reynolds number approach or by using a Reynolds number with some reduced viscosity term such as the plastic viscosity for Bingham materials, or the Bowen approach of correlating pipe flow data using another empirical formula. The main reason for using a Reynolds number was that one *may* need to be able to predict pipe flow data from viscoimetric measurements.

Dense concentrations such as occurs in cement pastes require careful treatment because here a heterogeneous system can occur with a water layer lying at the solid boundary.

None of the correlation methods have been verified over a sufficiently wide range of conditions but the comparative studies which have been carried out to date show that the Bowen approach gives much superior correlation to the Dodge-Metzner method for the same experimental data covering 20th solutions and slurries. There is a clear need for further reliable data in this field.

It was suggested that dense concentration transport has several advantages over dilute concentrations. This would apply for a liquid continuous phase as well as for a gas phase, of course dense concentrations are not always possible in practice.

The laminar-turbulent transition criterion was discussed originating with the idea that the friction factor rather than the Dodge-Metzner Reynolds number ($N \sim 2000$) gave the best indication of transition. A criterion based on the radial velocity gradient was also discussed but there appears to be insufficient experimental evidence to verify any particular criterion at the present time. All the criteria discussed do not apply if there is any "drag reduction" phenomenon.

(ii) *Trends for further work*

Some agreement was reached for pooling available experimental data for independent assessment. It is hoped to commence a comparative study of data from various sources in the near future. It is felt that where valid data are available this will be very beneficial in clarifying the field and providing a reliable review for future use.

Ultimately larger scale facilities will be required for pipeflow rig tests than those currently available to most research workers in the area of pipeline transport and discussion ended with the idea of a national installation which would be generally available for tests. The case for such facilities could not presage the assessment of existing data mentioned previously which would provide some of the premises and could be of first order importance.

List of Participants:

Dr. D. G. Bell	English China Clays
Dr. R. Browne	Taylor-Woodrow Res. Labs.
Mr. W. C. Brunton	National Engineering Laboratory
Mr. A. P. Cheesman	International Management and Engineering Group Ltd.
Dr. D. C. H. Cheng	Warren Spring Laboratory
Mr. T. C. Davenport	British Petroleum Ltd.
Dr. R. A. Duckworth	City University
Dr. M. Edwards	Bradford University
Mr. G. Fish	Brit. Hydromechanics Research Assn.
Dr. J. Harris	Bradford University
Mr. Tookey	Warren Spring Laboratory
Mr. B. L. Karavis	International Management and Engineering Group Ltd.
Mr. P. Langborne	National Engineering Laboratory
Mr. F. Loadwick	Taylor-Woodrow Res. Labs.
Dr. W. MacSporran	Bradford University
Dr. P. B. Smith	B.P.
Dr. H. Steen	Unilever, Port Sunlight
Prof. W. L. Wilkinson	Bradford University

1971 LITERARY AWARD OF THE AMERICAN CHAPTER OF THE SOCIETY OF COSMETIC CHEMISTS

It is a pleasure to be able to announce that the Society of Cosmetic Chemists has nominated Dr. Philip Sherman of Unilever Research Laboratory, Welwyn, Herts., to receive the above award. This award is given "... to the author of a publication or series of papers on basic research which is judged to be the most outstanding contribution to cosmetic science or technology during the preceding three years." Many members of the society will be familiar with the excellent standard, both from a literary and a scientific point of view of Dr. Sherman's publications, and would concur with the choice of the Society of Cosmetic Chemists and the terms of the above citation.

VICTORIA BRANCH (AUSTRALIA)

The A.G.M. of the Branch was held at Monash University on 29th July, 1970. We had a very enjoyable evening, a dinner followed by a talk on the "Rheology and the Food Industry" by Dr. K. Farrer, Research and Development Manager, Kraft Foods Ltd., Australia. This talk was then followed by the election of the new Council for 1970-1971.

PROGRAMME 1971

1. Friday, 19th March—a one-day symposium on Slurry Handling Theory and Practice to be held at Clunies Ross House. A total of six papers was received. Dr. Rama Murthy, C.S.I.R.O. Division of Chemical Engineering was the convenor.

- 1.1 Rheological Characteristics of Rapidly Settling Suspensions—Effect of Particle Size Distribution and Concentration.
D. Hornsby, Dept. of Mining Engineering, University of Melbourne, Melbourne.
- 1.2 Flow Properties of Highly Concentrated Suspensions of Spherical Particles in Rotational and Pipeline Viscometers.
R. J. Wiles, Dept. of Chemical Engineering, University of Queensland, Brisbane.
- 1.3 Slurry Pipeline Economics and Application.
N. Cowper, Bechtel Incorporated, San Francisco, California, U.S.A.
- 1.4 Transportation of Wood Chips by Pipeline.
K. R. Shellene, Shell Pipeline Corp., Houston, Texas, U.S.A.
- 1.5 Slurry Agitation.
K. R. Hall, Division of Chemical Engineering, C.S.I.R.O., Melbourne.
- 1.6 Slurry Pipelines in Australia.
M. J. de Rohan, Kinnaird Hill de Rohan and Young Pty. Ltd., Melbourne.

2. Thursday, 13th May. Combined Polymer Group and B.S.R. Meeting Dr. B. Cherry (Monash University)—Title Mechanical Properties of Semi-Crystalline Polymers.

3. Thursday, 17th June. Mr. A. Fincham (Fibremakers). The Rheological Properties of Nylon and Terylene.

4. Thursday, 15th July. Visit to Clay Works. Scoresby.

5. Annual General Meeting 26th August. Guest Speaker Professor Max Fenghelman. Topic—Possibly Carbon Fibre Technology.

6. October—Extrusion Symposium. Theory and Practice in conjunction with the Ceramic Society. Speakers and date yet to be finalised.

7. Starting in September a lecture course entitled Introduction to Rheology to be held at the University of Melbourne, similar to the series held a few years ago. The subject-matter will include phenomena observed in the flow and deformation of liquids and solids, instrumentation, structural interpretation in typical materials, and significance of these effects in various industries.

J. M. Stearne (Hon. Sec.),
C/- ICIANZ Central Research Labs.,
Newson Street,
ASCOT VALE 3032.

NOTICE

Cahiers du Groupe Francais de Rheologie

A recently issued supplement to Vol. 2 of Cahiers du Groupe Francais de Rheologie reprints the full texts, together with discussion of, 14 papers presented at a symposium on The Mechanical Behaviour of Composite Materials held in France on 20th and 21st November, 1969.

The papers, all in French, range from simple descriptions of engineering materials to reviews of methods of determining important structural parameters.

The latest issue of Cahiers du Groupe Francais de Rheologie is a special issue containing the papers and associated discussions presented at a conference on "Rheology and Hydrotechnology" held on 19th-20th March, 1970.

Papers include:

Rheological behaviour of liquids and suspensions (a survey)—
M. Joly.

Rheological behaviour of solids and pseudo-solids (a survey)—
D. Radenkovic

Measurement of rheological parameters (a review)—
D. Bellet and C. Thirriot.

The mechanical principles of continuous media (a review)—
P. Anglés d' Auriac.

The Boltzman principle and its application in the interpretation of experimental results—P. Le Roy and J. M. Pierrara.

Non-Newtonian fluids in French industry—
C. Thirriot and D. Amoros.

Viscoelastic effects in static and dynamic pressure measurement—
D. Fruman, G. Loiseau and P. Sulmont.

Grout rheology—C. Caron.

Characteristics, rheology and composition of drilling muds—
M. Martin.

Behaviour of stressed rocks as a function of their strength in water—P. Morlier.

The rheological properties of chalk and their effect on tunnelling—J. L. Dessenne and P. Duffaut.

The creep of ice—L. Lliboutry.

Both the above publications may be borrowed from Dr. D. W. Hadley, J. J. Thomson Physical Laboratory, Whiteknights, Reading RG6 2AF.

UNIVERSITY OF BRADFORD

Postgraduate School of Studies in Polymer Science

M.Sc. in Polymer Science by Advanced Study

Ph.D., M.Sc. by Research

Courses in Polymer Chemistry, Polymer Physics and Applied Polymer Science

Studies extend over twelve months and commence in October of each year. These are designed to provide a broad study of advanced polymer chemistry, polymer physics or applied polymer science, together with specialisation in related topics.

Research in

New Polymers, Physical and Mechanical Properties, Polymerisation, Rheology, Solution Properties, Structure, etc.

Applicants should possess a good honours degree in *chemistry, physics, or chemical engineering* (or related subjects) or an equivalent qualification, or be graduating this session.

Science Research Council and other studentships may be available for suitably qualified candidates and advice on other forms of financial support can be provided.

Application forms and further details can be obtained from:—
The Secretary, School of Polymer Science, University of Bradford,
Bradford, Yorkshire, BD7 1DP.

Society of Glass Technology

Preliminary Notice

GLASS CONDITIONING FROM THROAT TO ORIFICE RING

A two-day symposium will be held in the Memorial Hall of the Sheffield City Hall on Wednesday and Thursday, 24th and 25th November, 1971, when it is hoped that the following aspects of the above subject will be covered:

1. Working end design and requirements
2. Physical and refractory design of forehearths
3. Fuels for firing forehearths.
4. Temperature detection and control
5. Speciality items such as, stirring, closed forehearths, and colour additions

Contributions are invited and offers of papers should be made before 1st January, 1971, to the Chairman or Secretary of the Furnace Committee of the Society, whose addresses are given below.

Chairman: Mr. T. Burkinshaw, Beatson Clark & Co. Ltd., Rotherham, Yorkshire.

Secretary: Mr. R. P. Wood, Glass Bulbs Ltd., Harworth, Nr. Doncaster, Yorkshire.

VAN LEER (U.K.) LIMITED

Passfield Research Laboratories

Applications are invited for the following vacancy

RHEOLOGIST

to study rheological properties of thermoplastics in relation to their processing behaviour, and to advise on extruder and die design from a theoretical standpoint using computer techniques where appropriate.

Successful candidate for this post will be an Honours Graduate probably with a research degree, between 25 and 35 years of age and able to display initiative and inventiveness.

The laboratories which form the research centre for an international industrial packaging organisation, are well equipped and are situated in pleasant rural surroundings. There is a contributory pension scheme in operation and housing assistance is provided.

Please send brief details of age, present salary, qualifications and experience in confidence to:—

The Administrator,
Van Leer (U.K.) Limited,
Passfield Research Laboratories,
Passfield, Nr. Liphook, Hampshire.

University of Sheffield Faculty of Materials Technology (Dept. of Glass Technology)

LECTURER IN POLYMER TECHNOLOGY

In order to increase the scope of the teaching and research in the faculty a small group concerned with high polymer technology was set up within the Department of Glass Technology. We now wish to appoint a Lecturer with interests in the mechanical properties of polymers.

The existing research programme is strongly orientated towards composite materials and it is hoped that the new member will add to these activities.

Applications are invited from persons with suitable background and relevant experience.

Applications (3 copies) should be sent as soon as possible to the Registrar, University of Sheffield, S10 2TN.

Salary (to be revised in accordance with recent salary award) £1,355 x 125—£3,105, with F.S.S.U. provision.

PLASTICS INSTITUTE CONFERENCE TEXTILES FROM FILM II

6th and 7th July, 1971

University of Manchester Institute of Science and Technology,
Sackville Street, Manchester M60 1QD

PROGRAMME

Tuesday, 6th July, 1971

SESSION 1.—MATERIALS

1. Parameters affecting processing of polymers and polymer blends. W. H. Skoroszewski, Shell Research Ltd.
2. The influence of additives on processing and properties of film fibres. M. E. Evans, I.C.I. Ltd., Plastics Division.
3. Factors affecting the u.v. stability of polyolefin stretched film products S. L. Fitton and J. Gray, Shell Research Ltd. Discussion.
4. Dyeability and printing of film fibres, R. H. Roberts, I.C.I. Ltd., Plastics Division.

SESSION 2.—TAPE REPRODUCTION

5. Process and end products comparisons between film production methods, stretching and annealing techniques, J. Balslev, Jacob Holm and Sonner, Denmark.
6. Warp sheet, D. C. Hossack, Filtrona Textile Products Ltd.
7. Recovery of oriented polypropylene waste, A. H. Lawrence, I.C.I. Ltd., Plastics Division.

SESSION 3.—FILM YARN APPLICATIONS

8. Present and future applications for film fabrics in the U.S.A., A. A. Kerr, Patchogue: Plymouth Company, U.S.A. Discussion.
9. Developments in applications of film yarns in ropes and twines, A. E. Wills, Marlow Ropes Ltd. Discussion.

Wednesday, 7th July, 1971

SESSION 4.—FILAMENT YARNS

10. Mechanical fibrillation, R. Fletcher, Plasticizers Ltd.
11. Newer routes to fibre from film, J. Dow, Smith & Nephew Ltd.
12. G. J. Nichols, Shell Research Ltd.
13. Spinneret fibre versus film fibre, R. E. Nott, I.C.I. Ltd., Plastics Division.
14. Manufacture of spun yarns from film fibre, S. McMeekin, Lambeg Industrial Research Association.
15. Multicomponent film fibre developments, H. Mehta, Shell Plastics Laboratory, Delft, Holland.

SESSION 5.—APPLICATIONS OF FIBRES-FROM-FILM

16. Application of film fibre yarns in carpets, H. P. Stout, The Scottish Textile Research Association.
17. Staple in needle-loom carpeting, E. M. Dykes, Illingworth Carpets Ltd.
18. The future applications of filament and staple in non-woven fabrics, R. Krcma, Textile University, Czechoslovakia.
19. Applications for Raschel knitted fabrics, Dr. Krause, Farbwerke Hoechst AG, Western Germany.
20. Application of staple and filament yarn in upholstery fabrics and wall coverings, J. Sorez, Prouvost-Masurel, France.
21. The application of staple film fibre in concrete, J. J. Zonsfeld, Shell International Chemical Co. Ltd.
22. Future applications for film textiles, J. E. Ford and T. H. Govier, Shirley Institute.

Institution of Chemical Engineers

Institute of Measurement and Control

Symposium on "Flow Measurement of Difficult Fluids"

15th–16th April, 1971

University of Bradford

SYNOPSIS OF PAPERS

Review of Some Recent Flow Measurement Problems and Their Solution.
K. J. Zanker (G. Kent Limited).

The paper reviews in breadth rather than depth the range of difficult fluids encountered, the application of conventional flowmeters, some newer methods of flow measurement and performance rating. Liquids, gases, two phase systems, non-Newtonian behaviour, high viscosity, chemical properties, fire or explosion hazards and extremes of pressure, temperature and flow can individually or jointly cause difficulties in flow measurement. The industrially available flow meters, working on positive displacement, pressure differential, variable area, turbine or electromagnetic principles are limited and many newer methods are being explored. Flow may be required in volume or mass units and in terms of total quantity or rate. Accuracy, calibration, rangeability, linearity, reliability, life, maintenance, power requirement, cost and system compatibility will all contribute to acceptable performance.

Flow Measurement in the Food Industry. D. M. Bancroft and P. Sherman
(Unilever Research Laboratory, Welwyn).

The manufacture of food is often concerned with the conversion of low viscosity Newtonian liquids into highly viscous non-Newtonian systems. Examples of this can be seen in the conversion of edible oils into margarine, milk into butter or both into ice-cream. The range of viscosities encountered is therefore very large. The final products are often shear-sensitive, susceptible to damage by changes in temperature and liable to attack by bacteria etc. Consequently much of the production is carried out in sealed vessels and so the materials require pumping from place to place during the various stages of production. Many types of flow metering devices are used in monitoring the flows in the initial stages, but at the later stages a positive displacement pump of some form is almost invariably used. This reduces the possibility of degrading the product by shear, and has the positive advantage of accurately monitoring quantities of liquid.

Total Volume and Component Flow in Two-phase Systems Using Cross-Correlation Techniques. M. S. Beck & P. J. Mendies (University of Bradford).

Flow velocity can be derived directly from the transit time of natural turbulence signals between two transducers spaced along the direction of flow. The transit time is determined by cross-correlating transducer outputs with either a special purpose correlator or an on-line computer. The advantages are that the time delay can be measured absolutely by the correlator, the instrument is relatively insensitive to the effects of upstream disturbances and the transducers do not obstruct the flow of material. Results are presented for heavily loaded gas/solid systems using capacity transducers and sand/water slurries using electrical conductivity transducers. The mass flow of the solids component in two-phase flow can also be derived from measurement of variations in concentration intensity due to turbulence.

The Use of Ultrasonics in Cross-Correlation Flow Measurement. G. Calvert (University of Bradford) and J. Coultard (Teeside Polytechnic).

Flow velocity can be determined from the transit time of signals between two sets of transducers spaced along the direction of flow by the cross-correlation of the transducer outputs. Ultrasonic transmitter and receiver pairs are mounted diametrically opposite on the outside of the pipe or duct in which the fluid is flowing. If natural variations in density occur in the fluid due to temperature variations, turbulence, etc. then the absorption of ultrasound varies and the receiver will detect these variations. Preliminary results are presented for flow of air and slurries in ducts and pipes together with some results for milk flowing in a small pipe encased in a larger pipe.

Flow Measurement on Large Chemical Plants. D. L. Smith (I.C.I. Agricultural Division).

Accurate and reliable flowmetering on large chemical plants is not easily achieved, even with fluids not usually classed as "difficult." Difficulties can arise due to the nature of the fluid, the pipeline conditions, the quantity to be metered, or the large sums of money which have to be accounted for from flowmeter readings which imposes severe limits on accuracy. Examples are given of flowmetering concentrated ammonium nitrate, mixed vapour flow to a reformer, ethylene, natural gas, and excisable hydrocarbon fluids.

Flow Measurement of Viscous and Non-Newtonian Fluids. E. Muller (Courtaulds Limited).

The importance of a sound understanding of rheological behaviour in relation to the flow measurement of viscous and Non-Newtonian fluids and slurries is discussed. Relevant fluid properties are examined in relation to flow measurement techniques and experimental facts given. Both small scale experiments and experience on full scale operational plant units are reported in some detail.

Individual flow metering problems and difficulties on moderately and highly viscous fluids are investigated and practical solutions reported where possible. Various suitable primary flow elements actually used in practice on difficult metering applications are discussed.

The methods of selection, sizing and use of control valves in relation to a number of factual process control loops and applications are discussed, with special emphasis on flow characteristics and practical suitability. Desirable areas for further investigation are recommended.

Flow Measurement Using Microwave Radar Techniques. J. Harris (University of Bradford).

The use of a homodyne microwave technique using a Gunn diode as the c.w. radiation source is described. Radiation scattered from a target in motion

is mixed with a sample of the outgoing signal resulting in a beat frequency due to the Doppler frequency shift in the scattered radiation. The technique appears to show promise of a range of applications in the monitoring of transported material; initial trials have mainly concentrated on pneumatic conveying.

The Use of Orifice Plates and Venturi Meters with non-Newtonian Fluids. (J. Harris and A. Magnall (School of Chemical Engineering, University of Bradford).

Data is presented on non-Newtonian flow rate measurements in a two-inch diameter pipeline using four orifice plates with diameters of 1.20" (0.0304m), 1.25" (0.03175m), 1.38" (0.0349m) and 1.50" (0.0381m) and a venturi meter with a throat diameter of 1.25" (0.03175m). Several pseudo plastic polymer solutions have been tested and the experimental results are presented both as groups of the discharge coefficient against non-Newtonian Reynolds number and on an alternative correlation which appears more effective. An explanation of the results on a Reynolds number basis is given in terms of some of the basic factors affecting the discharge coefficient.

International Conference on MODERN DEVELOPMENTS IN FLOW MEASUREMENT

21st to 23rd September, 1971

Venue

Oxford and Harwell.

Sponsors

Atomic Energy Research Establishment, Harwell, and the National Engineering Laboratory, East Kilbride.

Aim and scope

The aim is to bring together scientists and engineers responsible for developing flow meters and flow measuring techniques with consultants, process engineers, hydraulic machine designers, users and others who have a strong interest in measuring the flow of liquids and slurries in open channels of regular cross-section and the flow of liquids and gases in pipes.

The emphasis will be on modern developments such as laser, ultrasonic, N.M.R. and thermodynamic flow meters and on tracer techniques. To establish a basis of comparison, the first day will be devoted to a series of review papers on conventional methods such as inferential, pressure difference and mass flow meters. River flow measurement is excluded as a topic.

DIARY

1971

- 6 and 7 July.** Conference—Textiles from Films Joint Plast. Inst., Shirley Inst., Textile Inst. meeting at Manchester.
- 29 August–2 September.** Symposium—International Symposium on Two-Phase Systems at Technion City—Israel.
- 21–23 September.** Conference—Modern Developments in Flow Measurement at Harwell A.E.R.E./N.E.L.
- 20–23 September.** Conference—B.S.R. Autumn Conference.
- 24 and 25 November.** Symposium—Glass Conditioning from Throat to Orifice Ring at Sheffield Soc. Glass Tech.

BRITISH SOCIETY OF RHEOLOGY

Computer Program Catalogue

Publication Abstract

1. Author
J. Harris and A. Jenkins
2. Establishment
Schools of Chemical Eng.,
The University, Bradford 7, Yorks., U.K.
Tel. No. 33466 Extn. 361
3. Program Abstract
Solution of Oscillatory pipe flow for Linear Elastic Fluids
Input Data
Reynolds numbers, boundary conditions
Output Data
Inphase/Quadrature Vel. Profiles
4. Program date
Jan. 1971
5. Language
6. Computer requirements
Analogue Eal. 680
7. Type of Input/Output
Handset Pot/Pen Recorder or Oscilloscope
8. References
9. Related programs
None
10. Available for copy/data processing
Copying only

Return to: Dr. J. Harris,
Postgraduate School of Chemical
Engineering,
University of Bradford,
Bradford 7, U.K.

Additional blank abstract sheets are available as required from the above address.

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The B.S.R. Bulletin is now available as a vehicle for several categories of communication by Members.

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2. Descriptive papers of general interest.
3. Letters which may be either
 - (i) technical or
 - (ii) non-technical.

The technical papers will be refereed and so will technical letters but the latter only by one person. Descriptive and non-technical material will be published if it is of general interest.

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