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INTERNATIONAL CONFERENCE ON
PRESSURE SURGES

This International Conference on Pressure Surges was sponsored and organised by BHRA Fluid Engineering, in conjunction with The City University London, and was held at Rutherford College, University of Kent at Canterbury, England 6-8th September, 1972.

These proceedings contain the papers presented at the Conference together with a record of the Oral Discussion and Written Contributions, Name and Subject Indexes and a List of Delegates.

Acknowledgements

The valuable assistance of the following persons in the successful organisation of this Conference is gratefully acknowledged:

Dr. K. J. Enever, The City University, London.
J. A. Fox, University of Leeds,
Dr. J. A. Swaffield, Polytechnic of the South Bank, London
A. R. D. Thorley, The City University, London

The editors especially wish to thank Stephen Schofield of the BHRA staff for his assistance in the preparation of these proceedings.

OPENING ADDRESS

It is a great honour to be asked by the BHRA to welcome you to this Meeting and to declare the Conference open. An undeserved honour - I was never (to use a hydrodynamic simile) on the glistening crest of the wave of progress, and am now an almost stationary particle in the dim region behind and below it.

When the Queen of Sheba heard of the fame of Solomon, she came to prove him with hard questions. Solomon told her all her questions - there was not anything hid from the King which he told her not. And when the Queen had seen all Solomon's wisdom, there was no more spirit in her.

I felt a bit like the Queen when I had tried to read - and here and there to understand - the wealth of papers submitted to this meeting. But I have enough spirit left in me to make me very grateful to the Authors, and to look forward with much interest to the elucidations and the discussions of the next two or three days.

One thing that struck me on reading the papers was that in so many of them space was devoted to the "peptinisation" of the information to be fed to a computer to make it digestible by the monster - and digestible, moreover in a minimum of computer-time. Could the Conference perhaps do something to reduce the resulting repetition?

Having recently been concerned in the study of the intermittent pumping of undigested gassy sewage sludge along long mains, I was specially interested in papers dealing with the analysis of the effects of varying bulk-elasticity (mainly resulting from varying pressures). Incidentally, the "softness" of sludge has, of course, the merit of cushioning surge or collision pressures, also of facilitating the starting-up of an idle column in a long pipe - the near end of which will often be up to speed before the outlet knows anything of what is coming. On the other hand, a measure of surge is, at starting, actually advantageous in breaking down, in the Bingham plastic, or pseudo-plastic, fluid, any initial shear-strength. But an impeller pump will usually impose sufficient surge, and the frequent preference for positive pumps is probably not justified, at any rate on this account.

Your time can be spent far more profitably than in listening to me. So, having congratulated the BHRA on having attracted such a galaxy of Hydrodynamicians and presented - so beautifully produced - such a range of Papers, I will sit down and allow your serious proceedings to start.

H R Lupton

Hugh R. Lupton

O.B.E., M.C., M.A., F.I.C.E.,
F.I.Mech.E., M.I.E.E., Hon.M.I.W.E.,
M.Cons.E., Consulting Engineer.

Proceedings of the 1st International Conference on Pressure Surges

CONTENTS

CLOSING SPEECH

Professor V. L. Streeter, University of Michigan, U. S. A.

The basic tools of transient analysis are now quite widely understood; although graphical analysis is in use in many engineering offices, the thrust of research papers is toward better mathematical simulations using the digital computer. Six years ago, in an international research conference on surge in England, more than half of the papers dealt with graphical analysis. The math model has developed rapidly and has replaced the physical model in many one-dimensional applications. The two- and three-dimensional problems remain almost completely in the physical simulation field as they are too difficult for analytical models.

Acoustic velocity prediction is our greatest problem in math models of transient flow. The reduction of pressure in a system by a transient, even when vapour pressure is not encountered, causes a large reduction in wave speed. Both maximum and minimum pressures are affected. To complicate the situation the wave speed is a function of both pressure and time. Air and other gases come out of solution and reduce wave speed when pressure is lowered, but the bubbles return back into solution at a lower rate. When vapour pressures are encountered a greater reduction in wave speeds takes place.

One must conclude from this conference that the trend in transient analysis is toward the use of the method of characteristics. An important problem arises in its use with systems having more than one pipe, and that is the satisfying of the Courant condition. It can be very serious for large interpolations. Other methods available include use of implicit reaches, which complicate programming, adjustment of wave speeds, or use of small incompressible reaches, referred to as "lumping". Some adjustment of wave speed seems reasonable, as it is not accurately known in most situations. When this is not adequate, lumping in such a way that the expression appears similar to a characteristic equation may also be used; these methods provide no complications in programming.

In this conference the paper by Kaplan, Belonogoff and Wentworth suggests a novel method they call "zooming", which has not been adequately tested at this time.

Of the thirty-seven papers presented, eleven dealt with special project simulations covering a wide range of applications. Each one cannot be discussed, but the work of P. T. A. Griffiths was especially interesting in that the study was very thorough and comprehensive, including electrical transients, governor characteristics, relief valves to control resonance conditions, air effects and open channel flow. The two papers by R. Svee and H. Brekke on compressed air surge chambers were also very significant.

Five papers were presented which used the impedance, or linear analysis, for steady-oscillatory flow cases. The paper by T. Ichikawa and K. Yamaguchi also dealt with a transient problem. Much can be learned from these methods, and with a computer program which is less costly to execute than with the characteristics method. This method is also subject to error if improper wave speeds are used.

Five papers were devoted to two-phase flow resulting from column separation. This is an important field that needs this research concentration. Prototype measurements of acoustic speeds during severe transients are required before this problem can be adequately handled in a math model.

Four papers dealt with incompressible analysis. In some cases they are more complicated than the compressible analysis and require use of the digital computer for results. The paper by M. Macagno and E. O. Macagno may provide help in the "lumping" of small reaches for the characteristics method.

Three papers were concerned with the method of characteristics. This small number of papers indicates that it is generally accepted and interest has turned to its applications.

There were also three papers describing "general" programs, i. e. programs which endeavour to solve any and all transient flow cases by properly imputing of the data. Large companies strongly endorse this approach, in part so that non-programmers may use the programs with limited transient understanding and so that the program is still easily used with changes in personnel. Compromises have to be made with these programs, with the actual case being adjusted to fit the program. The general approach, with its sorting and indexing is also more expensive to load and execute. Both special simulations and general programs will be used in the future.

Six papers dealt with a separate topic: numerical accuracy, non-Newtonian flow, visco-elastic flow, valve stroking, physical modelling, and pump characteristics interpolation.

To sum up the three basic problems requiring more attention are:

1. Acoustic speed determinations and predictions of acoustic speed during a transient.
2. Understanding of the basic physics of column separation, and
3. The handling of short reaches of pipe that do not satisfy the Courant condition $\Delta x = a \Delta t$

On behalf of the conference attendees I would like to thank Mr. Young, Mr. Stephens, Mr. Rowat and the other staff members of BHRA for the great efforts they expended in preparing for and carrying out this excellent conference.

SUBJECT INDEX

NAME INDEX

TO PAPERS, CONTRIBUTIONS AND DISCUSSION

In this index, papers presented at the Conference are denoted by bold print.

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