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BOOK REVIEW

Slurry Flow: Principles and Practice, by C. A. SHOOK and M. C. ROCO. Butterworth-Heinemann, New York (1991). US$75.

The authors are two of the most experienced workers in the world on hydraulic transport and an up-to-date assessment from them of the current state of knowledge, covering both fundamentals and practice, is very welcome. They are really trying to accomplish an impossible task in the course of 300 pages; covering as they do a background of particle technology, single-phase flow and the characterization of non-Newtonian fluids, as well as current developments in the modelling of the flow of suspensions and practical aspects of equipment selection and layout of installations.

A background of fluid mechanics and mathematics is assumed (as stated in the Preface) and therefore one may query the necessity of an introduction on single-phase flow which may be redundant for the knowledgeable and, at the same time, be too condensed to give any real feel of the topic to those who are new to the field. Inevitably, it is necessary to be highly selective in the presentation of formulae and correlations but the early chapters do give a good introduction to the literature on fluid–particle systems, generally well-referenced, but with some omissions (e.g. to equations 1-16, 1-23 etc.). Maybe a general reference to textbooks such as Clift, Grace and Weber, would be appropriate—though reference is made to this work in particular instances. When it is necessary to be selective, one might query the relevance to slurry transport of heat and mass transfer to spheres (pp. 19–20).

In discussing aspects of fluid–particle behaviour, it could be advantageous to add a few words about the relevance of the various topics to slurry transport. Thus, a knowledge of the characteristics of fluidized systems provides valuable information which can be applied to vertical transport. It can be helpful to point out the significance of some of the equations. Thus, the consequence of equations 2-36 and 2-37 is that there is something like a 60-fold range of velocities over which a fluidized bed can be formed for $Re_s < 2$, compared with only ~ 8-fold for $Re_s > 1000$. It is also important to give a feel for the accuracy of predictive methods. Thus, although the correlation of Oroskar and Turian for deposit velocity is quoted as being within $\pm 20\%$, exponents are quoted to 4 significant figures (0.1536 for C_v and 0.3564 for $1 - C_v$)!

Nowhere is the degree of confidence which can be placed on calculated results more important than in the case of horizontal transport of non-homogeneous slurries. Historically, it had been customary to relate the excess pressure gradient due to the presence of the solid particles to some form of modified Froude number, as in the work of Durand and Condolios. However, a look at the experimental results available from a number of workers will show a very wide scatter, sometimes over a span of an order of magnitude or more, and it is important that the reader be made aware of this. Equation 5-7 is quoted as being "a common version" of the equation; this needs qualification. The poor predictions given by these empirical equations have arisen partly because some of the important variables have not been taken into account, or their values have not been quoted in many of the papers concerned. More importantly, they do not take account of the mechanism of the flow process taking place in the pipeline.

Much attention has focused in recent years on the "two-layer" model in which the flow is considered as being divided between an upper layer, in which particles are supported by fluid lift forces, and a lower layer, where the weight of the particles is transmitted to the wall of the pipe as a result of particle to particle contacts. The difficulty of applying the model is that it involves the necessity of being able to predict conditions within the pipe, such as concentration distribution of solids and velocity profiles of the individual phases. In experimental investigations some of these quantities can be measured, but they will not be known in a practical design situation and it is therefore necessary to make some estimate of at least one of the in-line parameters. Commonly, the interfacial shear at the boundary between the two hypothetical layers is estimated but there is no easy way of checking the reasonableness of this value. Alternatively, the mean "slip velocity" may be estimated or, as in the case of the example given in the book, the ratio of the concentration of the contact load (i.e. in the lower layer) C_c to the mean in-line concentration over the whole cross-section C_r. The sample calculation relates to the transport of sand of particle size 0.5 mm and the ratio C_c/C_r is calculated iteratively using equation 6-5 which is a "tentative" correlation applying to values of the Archimedes number Ar not exceeding 3×10^5. This value is then used to calculate the hydraulic gradient (0.102 m/m). With the constraint on the maximum value of Ar, this calculation would be valid for particles of sizes up to 3 mm only, and therefore the method does not afford a means of calculation for coarse solids. It would be useful to know the ranges of the individual variables covered by equation 6-5.

What the designer would really like to know is the degree of confidence which can be placed in the results of calculations of pressure gradient, and it would have been useful for the results of applying several methods of calculation for a particular case to be given, and an assessment made of their reliability. As indicated in the text, the models are being constantly up-dated and much help is likely to be gained from the results of work described in the very useful chapter on microscopic modelling.

The book concludes with chapters dealing with problems of sometimes over-riding practical importance, including designing installations to reduce wear and the very large associated maintenance costs. There is much practical information on pumps and feeders and on the effects of pipe fittings and the layout of the system. In addition, there is a wealth of information on instrumentation, which is of special significance to those engaged in experimental programmes.

The subject area of this book is a very difficult one, both from the point of view of understanding the mechanisms of two-phase flow and of translating this understanding into the practical design of the plant. The authors are to be congratulated on presenting a very readable account, both of current knowledge and of areas where work is proceeding which will extend the tentative proposals so that they can be applied with an increasing degree of confidence. It is recommended reading for anyone working in the area, either on research or on the design of installations. In reviewing a book of this sort one tends to pick on particular points which catch the attention, and this may give undue emphasis to areas where one has criticisms. This work will need continual updating as our knowledge-base is increased, and it is hoped that some of the points raised in this review may be helpful not only to potential readers but also the authors when the time comes to make revisions.

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