Book Reviews

Creep and Relaxation of Nonlinear Viscoelastic Materials

W. N. Findley, J. S. Lai and K. Onaron

North Holland, 1976, 368 pp

$34.50

This is an advanced book for specialists. It is written by three authors well known for their contributions to the field covered in the text and the presentation is, in the main, detailed and authoritative. The text is principally concerned with the development of the multiple integral representation of the deformational behaviour of materials which show non-linear viscoelasticity. An attempt is made to show how the theory can be used to describe experimental data and perhaps extended to predict some aspects of deformation in engineering problems. The treatment of experimental data is on a limited scale, if only because a relatively small amount of suitable data is available.

The whole is concerned with *description* of behaviour. No attention is paid to the relation between structure and properties. Material, whatever its structure, is regarded as a homogeneous continuum and treated accordingly. Inevitably most of the data presented relates to polymeric materials and composites, it includes data on solid plastics (polyurethane, polyvinyl chloride, polyethylene etc.), asbestos and glass fibre reinforced plastics, paper and fabric plastics laminates, canvas and wood. Very brief references are made to metals and concrete. The authors do not attempt a comprehensive survey of available data they simply pick out examples of data which has been analysed in terms of the theory presented.

The book can be divided into two parts. The first part (approximately 40% of the main text) contains a general introduction, a historical review of creep, an introduction to the definition of stress, strain and the mechanics of deformation and an introduction to linear viscoelasticity and linear viscoelastic stress analysis. This part sets the scene for the more advanced and specialist work in the major part of the text.

In this first part the subject matter is sometimes presented rather superficially introducing the technique and notation used later. For example the basic mechanics is presented in Cartesian tensor notation and the authors take care to introduce the notation in a way helpful to those having little familiarity with it. However in general this part is probably more valuable as an attempt to order the subject for those already having some knowledge of it rather than as an elementary text for the newcomer.

The historical review covers a variety of empirical creep relations, mainly applicable only to simple loading situations and used mainly in metals; this is followed by an outline of both the differential and integral approaches to linear viscoelasticity. The description of stress as a tensor quantity is presented at some length but strain is dealt with much more briefly and the problems of finite strain description are surprisingly ignored. The reader is left with the usual definitions of the tensor and engineering components for infinitesimal strains and these are used throughout the book. There is no discussion of non-linearity at finite strains beyond the remark that most materials show non-linear behaviour at 1 or 2% strain or even less and that the boundary between non-linear behaviour and what can be accepted as linear behaviour is arbitrary. Reference is made to linear elastic theory but non-linear elastic theory is not included even briefly.

The treatment of linear viscoelasticity is standard and relatively brief. Temperature effects are almost ignored except for a very brief and oversimplified reference to time–temperature superposition and the WLF equation. The treatment of linear viscoelastic stress analysis is also brief and focused on the elastic–viscoelastic correspondence principle.

It is in the second part of the book, in which the authors present a detailed discussion of a multiple intregral representation of non-linear viscoelastic behaviour, that the real merit of the book lies. A detailed and logical presentation indicates the difficulties and the utility of using the theory. The attitude throughout is to focus on possible practical uses of the theory in describing experimental results and the discussion weighs the complexity of generality against the simplifications obtained by accepting various restrictions. Whilst the algebra is formidable in quantity, the presentation draws out major results in the simplest possible forms and in conventional notation so that various results can readily be used and compared.

The multiple integral representation is presented as an extension of linear superposition to the non-linear range, for small deformations in both uniaxial and multiaxial loading. Restrictions discussed include linearly compressible and incompressible behaviour and the superposition of small, time-dependent deformations on large deformations.

Discussion proceeds to various special cases of creep and stress relaxation including interconversion between the two and mixing of the two. It also includes creep and stress relaxation under varying loads and deformations and the effects of temperature and temperature variations.

The possibility of engineering applications of the theory is illustrated in a chapter on non-linear viscoelastic stress analysis including torsion of shafts, bending of beams and deformation of tubes.

Finally there is a brief chapter on the experimental difficulties associated with the high precision measurements necessary for critical application of the theory. This discussion is general but does include some mention of the highly sophisticated apparatus and techniques which have been developed by the authors.

The whole book is not a comprehensive work on creep and relaxation. There is a large amount of physical and engineering work which is not mentioned. It is a monograph giving details coverage of one part of the whole subject. The authors put to themselves the objective of 'presenting the material in such a way as to be readable and useful to designers as well as to research workers and students'. In the event only designers with very particular problems and outlooks would be likely to contemplate such complexity.

D. W. Saunders

Encyclopedia of PVC Volume 2

Edited by Leonard I Nass

Marcel Dekker, New York, 1977

S. Fr 240

This is the second of three volumes. The first volume covered PVC polymerization, structure, testing, stabilization and plasticization. This second volume is mainly concerned with additives, mixing, compounding and rheology. Some readers may be initially disappointed to read in the preface that no attempt has been made to provide a formulary of compounds. Even so, typical formulations appear in the chapter on compounding together with the technical reasoning behind their derivation. Technologists who can find the time to read through the large volume of over 1200 pages should be in a better position to derive their own formulations with consequential technical and economic advantages over using 'inherited' ones.

The first chapter covers modifying resins. Emphasis is placed on MBS types with a reasonable coverage of ABS, CPE and acrylics. Brief coverage is given to ethylene copolymers, rubbers, chlorinated paraffins and treated calcium carbonates. Lubricants are for once treated with the importance they deserve with data covering such important factors as fusion effects, output rates, and clarity. The chapter on fillers also fills a gap where information is generally lacking, particularly the effects on physical properties, economic aspects and fire resistance. Other sections deal with pastes, mixing and compounding equipment, process control and melt rheology.

With one exception, each chapter has a useful list of references but one wonders why there are so few later than 1970. Although confined to ASTM, the list of common control tests provides a useful reference.

Few would disagree with the editors comment, 'there exists a paucity of hard-bound technical reference literature on the subject' (of PVC), so that volume 3 covering extrusion, injection moulding and other conversion topics should be of equal interest when it appears.

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