

Book reviews

A First Course in Electrochemical Engineering, by F. C. Walsh

374 pp, The Electrochemical Consultancy, UK, £10

This is an introductory text to the subject of electrochemical engineering written in eleven chapters. The central theme of the book is perhaps not surprisingly the electrochemical reactor.

Chapter 1 defines the subject area of electrochemical engineering and the scope of the activity in industry. This is written around the author's personal experiences. Chapter 2 discusses the varied range of electrode reactions and types of cells which occur in industry, providing a thermodynamic basis for the electrochemistry. Chapter 3 identifies in detail the components which make up the electrochemical cell, i.e. the electrodes, the electrolyte and also electrode separators. The range of materials, their functions and operating characteristics are also described. Chapter 4 goes through familiar but important basic material on electrode kinetics and rate processes. Chapter 5 focuses on the area of hydrodynamics and mass transport. There is some interesting experimental detail on the measurement of variations in localized mass transport in electrolytic cells. Chapter 6 brings in the concept of the electrochemical reactor by defining the principle types of devices. The design approach to reactors is described with reference to reactions which are under mass transport control. The range of performance indicators which can help characterize the performance of reactors under limiting conditions of operation are described. Chapter 7 looks in more detail into electrochemical reactor design and highlights the importance of current and potential distribution. The chapter also stresses the importance of the integration of the reactor with other process equipment. The author defines what we would really like from an electrochemical reactor and counters this by pointing out the many limitations which have to be accommodated in practical systems. This then leads nicely into the next chapter, which classifies and describes the different types of electrolytic reactors which are of practical interest. Chapter 9 effectively completes the book by giving some general insights into electrochemical technology and describes in some detail three examples of important application areas; electrosynthesis (organic), metal ion removal and electro-dialysis salt splitting.

A set of five useful worked examples which cover basic calculations in electrochemical engineering are provided as an additional 'Chapter 10'. Finally, yet another Chapter, 11, concludes the work by identifying developments in the coming future for the discipline of electrochemical engineering.

The work generally takes a lightweight approach to

the engineering of electrochemical processes relying on simple models and their solutions. There is an absence of detailed mathematical treatment which require numerical methods in solution. This is to be expected and is a good approach for an introductory text to the subject. The emphasis is on the construction, analysis and behaviour of the electrochemical reactor, giving both fundamental scientific and engineering background as well as valuable practical information on the performance of cells and the experimental equipment.

The reader should not expect to find too much in the way of physical electrochemistry or in fact detailed chemical engineering. The work will however satisfy scientists and engineers alike who are looking to acquire a familiarity and a feel of the basics of the subject, as well as the areas of application.

The book would be a useful text for undergraduates who are undertaking a first course in electrochemical engineering. As a softbound book it provides value for money.

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Nickel & Chromium Plating 3rd Edition, by J. K. Dennis and T. E. Such

499 pp, Woodhead Publishing, 1993, £75
ISBN 1 85573 081 2

From time to time one reads about journalists taking a sabbatical in order to write a book. Typewriter in hand, they retreat to an Italian villa, emerging after six months triumphantly clutching a completed manuscript. This book reminds one forcibly that, in our discipline at least, the 'Italian option' is not on offer and without easy access to a well-stocked library, it is simply not possible to write an authoritative monograph such as this sets out to be.

For anyone familiar with the subject, it becomes clear within a few minutes of opening this book, that the magnitude of the task they set themselves has overwhelmed these authors.

In essence, the scope of the book covers electro-deposition of nickel and chromium, electroless deposition of nickel and the properties of these deposits. Also treated are electrodeposition of nickel alloys, multiplex coatings of Ni + Cr and a handful of other topics such as high speed plating, plating onto plastics etc.

In the authors' favour is their unambiguous declaration that (I paraphrase) 'this is not a practical man's book'. Fair enough, it must therefore be a book for those in R & D or perhaps those whose task it is to select coatings for a particular application. Let us therefore seek to judge it in these terms.

Two of the chapters 'Autocatalytic Deposition of Nickel' and 'Electroplating onto Plastics' relate to subjects so important that they have formed the subject of several monographs in their own right. In the former case, the subject receives 19 pages and 86 references. By contrast, a 1991 monograph on 'Electroless Nickel' (not even mentioned by the authors) runs to 310 pages and 739 references. The authors include in their bibliography, the book by Gavrilov on the same topic. The English translation was published in 1979 and has been out of print for some years now. The Russian original dates back to 1974 or so. Using the 'Surface Finishing' CD-ROM, the reviewer came up with around 500 references.

'Electroplating onto Plastics' rates 31 pages and 108 references. None of the books (the writer is aware of three) on this subject are even mentioned. One at least of these includes around 400 references.

Chapter 13 is 'Deposition of Nickel Alloys' and is interpreted by the authors not (as most readers might have thought) as 'nickel-based alloys' but any electro-deposited alloy containing even as little as 1% Ni, e.g. for hardening gold. There were 131 references cited compared with 900 found using the Surface Finishing CD-ROM. While the reviewer is duty bound to declare his interest in the latter, he can by the same token affirm that, in compiling it, the policy was to include only significant papers or patents.

By now it should be apparent that, whatever its merits, there is no way the book can lay claim to provide even a near-comprehensive treatment of the subject. So much for omissions. But, unless I am mistaken, there are errors too. On page 252, a section deals with the Acetic Acid-Salt Spray corrosion test, referenced as ASTM B287-80. As I recall, this test was dropped from the ASTM category back in 1986 or so. Nor does this section reflect a growing trend to accelerated corrosion tests which are cyclic. The Kesternich was an early attempt in this direction and has near-equivalents under both BSS (5466, part 8) and ASTM. Neither are mentioned and this test which is not just used but is popular in Germany, Austria and elsewhere is assigned a fairly obscure 1951 reference.

Reading through the chapters and gauging the references in terms of their sources and dates, one increasingly concluded that it was the updating of the 2nd Edition which proved so daunting a task for the authors. Two last tests related to a couple of hot topics which fall within the scope of the book. The first of these was trivalent chromium plating. Compared with well over 100 citations on the CD-ROM, we are offered perhaps 10 or so, with heavy emphasis on one of the author's (TES) own work prior to his retirement as Research Director at Wm Cannings. The second topic was sulphamate nickel. This is not even mentioned in the index and receives pretty short shrift on page 75 and Tables 4.1 and 4.2. By contrast, the CD-ROM clocks up 160 references. There is a brief section on electroforming which does little more than offer a superficial awareness.

In conclusion, for those new to the subject, the book contains a wealth of facts, graphs, tables and as such, it is undoubtedly useful. Much of this data remains valid today, even if published 20 years ago. But the evolution of the subject over the past 10 years or so is not fully reflected. Much has been omitted. Let no one believe that the 1993 date of the imprint in any way guarantees the reader a state-of-art overview.

If there should be a 4th Edition, one can only hope that the authors will trim away the peripherals, not offer readers a pale shadow of what can be found in other, more specialized, monographs and focus on the core of the subject, the electrodeposition of nickel and chromium.

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Electrochemical Oxygen Technology, by K. Kinoshita
400 pp, John Wiley & Sons, USA, 1992, £98
ISBN 0 471 57043 5

The chemistry of oxygen is dominated by its molecular electronic structure: although the thermodynamics of oxidation reactions is in general very favourable, spin inversion makes their kinetics slow. This is rather fortunate for the continuity of life as we know it, but creates great difficulties for the use of oxygen, for instance, as a fuel, in order to preserve us all from choking the environment with substances that in the end will kill us all. To utilize oxygen in a useful way, for example in fuel cells, not only its coordination chemistry must be controlled but also the engineering problems associated with a gaseous reagent that participates in a three phase reaction (gas, liquid, solid) must be solved.

This excellent book addresses mainly the technological problems identified with the electrochemistry of oxygen. However, the first two chapters bring a concise summary of current thinking on the mechanisms of both oxygen reduction and evolution reactions. Although the topics covered have been carefully chosen for their technological relevance, these include a comprehensive discussion of modern mechanistic and structural aspects of oxygen electrochemistry, for instance, reaction pathways, the interpretation of polarization curves, electrocatalysis and particle size effects.

The rest of the book is organized as a comprehensive and thorough review of technological applications, with an authoritative description of electrode preparation, fuel cells, O₂/air batteries and other industrial uses of the electrochemistry of oxygen. Topics covered include, amongst others, polymer electrolyte, alkaline phosphoric acid, molten carbonate and solid oxide fuel cells, various metal-air batteries, oxygen cathodes in the chloralkali industry and oxygen and ozone production. This material is presented in the form of an encyclopedia of technology, covering all the important aspects of the subject, from a description of actual preparation

techniques and experimental results, to the analysis of the engineering of practical devices. It is very interesting to the reader to have an insight of the author's critical views as to where the technology is going and which new areas are likely to be developed. The most important results and comparisons of performance are presented in tables, which makes this book self contained as a reference text.

Although the book is mainly targeted to people working in electrochemical technology, it represents a comprehensive description of the state of the art

not only in the electrochemical engineering associated with the use of oxygen but also on the science underlying this important industrial area. The author is to be congratulated for the great deal of effort and thought that he has obviously put into producing this book, which is strongly recommended for anybody dealing directly or indirectly with fuel cells, batteries, electrochemical engineering and corrosion.

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