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Book Reviews

Applied Probability for Engineers and Scientists, by Ephraim Suhir, The McGraw-Hill Companies, Inc., New York, NY, 1997. 587 pages. Price: $65.00.

REVIEWED BY ANTHONY J. RAFANELLI[1]

One comment to all readers and users of Dr. Suhir's book is as follows: "It is not just a book on probability." This comment should be remembered at all times or one may shortchange his/herself on the use of this book. With this comment, this reviewer is trying to impress upon potential users that probability theory applies to much more than statistics and rules of chance. Accordingly, Dr. Suhir has organized the book in such a manner as to give the practicing engineer the means to use probability theory in many real-life situations.

The first six chapters address some basic concepts, such as random events, discrete and random variables, systems and functions of random variables, and entropy/information. Particularly, in Chapters 2 and 3, the author has done a very nice job of expressing the distinction of discrete and continuous variables. The associated distributions for each type are concisely summarized along with guidelines as to their use. Plenty of examples are provided as guidance for easy application. These two chapters lend greatly to the book's usefulness in reliability engineering. Moreover, in Chapter 6, the concept of entropy is presented and well explained in terms of the degree of uncertainty in the outcome of an experiment or as the state of uncertainty of any system.

Chapters 7 and 8 discuss the random processes of correlation and spectral theories, respectively. One comment for future improvement is that an overview located at the beginning of each chapter explaining the distinction between the two theories would greatly enhance the book. Such a distinction, for the present edition, was not clear to this reviewer. However, within each chapter there is discussion regarding guidelines on the use of each.

Chapter 9 addresses extreme value distributions. The effectiveness of the author's examples is manifested by several situations, including application of extreme value distributions in reducing casualties at sea. The sample problem looks at three practical problems regarding (1) under-keel clearance for a ship traveling over a shallow waterway, (2) helicopter undercarriage strength considerations while landing on a ship's deck during high seas, and (3) probability of ship damage in high seas.

Reliability is the focus of Chapter 10. Deterministic and probabilistic approaches are presented. The author does a nice job of presenting the relationship between the reliability function and failure rate. Also included are goodness-of-fit criteria, reliability of repairable items, confidence intervals, accelerated life testing, technical diagnostics, and structural reliability. The accelerated-life test section provides a comprehensible presentation of acceleration factors. The section on technical diagnostics is interesting as it portrays the state of a system from the point of view of its propensity towards failure. The structural reliability section brings to one's attention the option of approaching strength evaluations by using reliability approaches. Some of the examples interestingly enough address solder glass attachment in ceramic electronic packages and strength considerations in the integrated circuit of a "smart card."

Chapter 11 relates the concept of a Markovian Process and uses it to describe a process in which the probability of any state of the system characterized by the process in the "future" is dependent only upon its state in the present, while independent of how the system reached the "present" state. In other words, the present state of the system is independent of previous events in the process history. According to the author, many everyday engineering problems can be modeled as Markovian, such as responses of some dynamic systems, optimization of dynamic systems, and controlling stresses in mechanical systems.

Chapter 12 discusses Random Fatigue. The chapter begins with an overview of the basic concepts (e.g., Goodman law and the linear accumulation of damages). The author reminds the reader of two considerations in evaluating fatigue effects: limited fatigue and steady-state fatigue regions of the Wohler curve. Fatigue failure in the limited fatigue region of the curve is due primarily to accumulation of shearing plastic deformation, while failure in the steady-state region is due to diffusion processes of dislocation motion. The presentation of a probabilistic approach to fatigue life determination provides a more complete method for accounting for actual loading conditions.

In Chapter 13, random vibrations are focused upon. Applications include (1) vibrations of elastic systems (specifically for such cases as nonlinear vibrations of rectangular plates, steady-state vibrations of linear elastic systems, and free vibrations with random initial conditions), (2) nonlinear vibrations (nonlinear random vibrations, statistical linearization, Fokker-Planck equation for both elastic and one-degree-of-freedom nonlinear systems), and (3) periodic impulses (instantaneous periodic impulses, linear vibrations, nonlinear steady-state undamped vibrations, stochastic instability and vibrations of an elongated plate due to periodic impulses). One note worth mentioning, in the section regarding applications to elastic systems, is the distinction made in analyzing random excitations of low intensity versus that for highly intensive excitation; in the former situation, statistical linearization is used providing a simple, straightforward approach whereas for the latter case, the solution approach is based upon the relationship between the correlation time and the system's time constant.

Chapter 14, while short in length, provides some key insight into geometric tolerances. The author presents his case that, although usual engineering practices approach geometric tolerances as deterministic (i.e., having finite limits), in truth the actual data (measurements) are random. Thus, consideration

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should be given to applying a probabilistic approach, "to quantitatively estimate the effect of the dimensional variability on the performance of mechanical elements and to keep this variability within allowable limits." Discussion is also provided on confidence limits in collecting such data as parts dimensions.

Whether it was the author's intent to save the best for last or not, Chapter 15 manifests itself as one of the most useful of the whole book. Entitled "Random Loads and Responses in Some Engineering Systems," material is presented for several "platforms" such as cars, ships, aircraft, and earthquakes. Each is addressed in its own section showing typical loading and response profiles. Equations are presented in a general format facilitating direct application, by professional engineers, for specific cases. Also, this chapter appears to be an excellent summary of most concepts discussed in the previous chapters.

In concluding, two general remarks can be made. First, the book has been organized such that it serves as an excellent handbook/reference type of tool in addition to being a very good text (perhaps graduate level). Second, the use of many, many examples, in every chapter, strengthens the effectiveness of this work, especially, as previously mentioned, in Chapter 15 where the material is presented for specific moving "platforms." This book is highly recommended for the engineer's library.

Modern Solder Technology for Competitive Electronics Manufacturing, by Jennie S. Hwang, Ph.D., The McGraw-Hill Companies, Inc., New York, NY, 1996. 622 pages. Price: $75.00.

REVIEWED BY ANTHONY J. RAFANELLI[2]

Dr. Jennie S. Hwang's book focuses on an industry need for understanding soldering technology from a real-life, everyday point of view. The title alone serves to emphasize Dr. Hwang's objective in making industry understand that increased discipline is needed in the manufacturing operation of today in order to succeed in the global economy.

The book is organized into twenty chapters, some of which address the traditional topics in solder technology, while others address specific topics (e.g. lead-free solders, strengthened solders, special topics in soldering issues, etc.) that normally would be chapter sections or merely mentioned in side notes. It is these specific topical chapters that make the book unique and perhaps, with the dynamic nature of the electronic industry today (especially from a manufacturing point of view), it is these chapters that the reader should concentrate upon.

Chapter 1 addresses market trends and, as such, technological demands are well covered. Perhaps, to put soldering technology in the right perspective, it would have been advantageous to overview other interconnection technologies and, moreover, the advantages of solder to them.

Chapter 2 covers advanced surface mount and die attach technologies and is nicely organized in presenting the two approaches. Surface mount technology (SMT) configurations discussed include flip chip, TAB, chip-on-board, fine pitch, QFP, and BGA/PAC technologies. Other areas covered include MCM, module-level packaging, hybrid of array/peripheral IC packaging, PCMCIA, and chip scale packaging technologies. Each SMT section begins with a brief overview and is then further organized into subsections on merits/limitations and system/process; the latter defining how each surface mount configuration is made. Illustrations are provided, some of which could be improved by additional captioning. However, these sections are more than adequate in providing descriptions of the various surface mount configurations and technologies. The die attach technology sections provide plenty of detail in describing the advantages/disadvantages and the processes of each type.

In Chapter 3, an abundance of good, appropriate data is provided including phase transition temperatures of virtually every solder alloy. Also, the author presents a series of plots comparing resistivity of metals with temperature, oxides, and plastic deformation. There is also discussion on antimony effects which includes resistance versus antimony content charts. The chapter goes on to include discussions on thermal conductivity, CTE versus temperature, surface tension, and mechanical properties. Along with metallurgy of solder, data is also provided regarding solder alloy selection criteria which includes a tabulation of worst case use environments of electronics—an apparently very useful cache of information.

Chapter 4 deals with solder chemistry. The author provides a very nice overview on fluxes including their purpose, strength, and types. Rosin chemistry is discussed. The discussion includes data disclosing weight loss with respect to different forms of heating. The chapter also includes alternative methods of fluxing, classes of flux, and a discussion on water clean and no-clean options with insight on selection between the two.

Chapter 5 addresses solderability and includes discussion on components and boards. Chapter 6 deals with solder microstructure and has a plentiful supply of micrographs showing morphology for many alloys. Chapter 7 covers solder paste technology and includes a nicely done presentation on rheological properties with explanations on paste slump, cohesive force, and surface tension. The topic of Chapter 8, aqueous-clean and no-clean manufacturing, includes not only a technical discussion, but information on cost considerations which help illustrate comparisons between the two methodologies.

Chapter 9 focuses on controlled atmospheres and provides thorough discussions on the subject including comparisons of reactive or protective controlled approaches. Information is also included on key characteristics of a gaseous atmosphere. Another section on key process parameters appears to be very amenable to those manufacturing professionals. Plenty of data is provided on gas flow rates, humidity/water vapor pressures, belt speed, temperature, oxygen level, and internal gas flow patterns.

Chapter 10 addresses surface mount fine pitch technology and comprehensively covers general factors for consideration, such as materials (e.g., paste rheology), processing (solder precoated, printing), and solderability. The solderability section (specifically for fine pitch QFP leads) provides in-depth information on five alternative rates for reflow. In Chapter 11, discussion is centered on BGA technology that includes presentations on BGA package types, materials/processes, solder interconnection reliability, coplanarity, soldering defects, and cost considerations.

Chapter 12 is centered around soldering methodologies with beginning sections on soldering heat sources (e.g., conduction, infrared, vapor phase, etc.), heat transfer, soldering principles, and mass reflow methodologies. Also included is information on process parameters including reflow temperature profiles.

Chapter 13 discusses special topics in soldering related issues. The chapter is unique in that the information provided could serve multiple purposes, such as a comprehensive tool in understanding the details of various aspects related to good soldering, as an aid for failure analysis, and as a source of quality criteria in preventing defects. Issues such as intermetallics, gold plating, solder balling, solder joint voids, contamination, plastic packages, thermal management, and electromigration are included. Particularly noteworthy, in the contamination section, are charts illustrating measured dissolution rates of common electronics elements into Sn-Pb solder. The section on plastic package cracking is timely given the current state of plastic encapsulated microcircuit usage in the industry today.

Timeliness of topics continues in Chapters 14 and 15 which cover strengthened and lead-free solders, respectively. Chapter

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