Journal of Pressure Vessel Technology

Book Reviews

Theory and Design of Pressure Vessels, Third Edition, 1985, by John Harvey, Van Nostrand Reinhold Company, Inc., New York, $48.95.

"This book is intended to serve as an introduction to pressure vessel design for the student by presenting the fundamental theory, and as a design basis for the practicing engineer by demonstrating the application of this theory with illustrations and examples of the solution of practical problems. In each chapter, design methods are illustrated by numerical problems in which the arithmetical work has been made simple in order to focus attention upon the theory involved, thereby avoiding the danger of it becoming merely a mechanical operation with an incomplete understanding of the theory and its significance. A considerable amount of new material and references have been added in a manner so as to preserve an orderly presentation. The result has been a complete revision and substantial increase in the size of original text, including a new chapter on buckling collapse. The latter has been prompted by the rapid growth in undersea exploration and mineral mining potential. Deep diving submersibles, offshore platforms, and deep drilling casings have made a priority of light weight, high strength materials in order to save weight and costs. The result is that elastic and plastic buckling instability have become increasingly important as failure modes.

Chapter 1 introduces the basic design considerations, analytical and experimental stress analysis methods, and the interaction of material properties and fabrication methods. The significance and consequences of applied and residual stresses under service loading and operating environment are emphasized. Pressure vessel terminology is presented, and basic membrane ligament theory developed.

Chapter 2 covers the basic theory of membrane stress and deflection analysis of axisymmetric vessels and its application to commonly encountered cylinders, spheres, ellipsoids, cones, and tori. An analysis of intersecting spheres and diaphragm vessels, upon which many deep diving oceanographic submersibles are based, is presented. Correspondingly, instability in the knuckle region of large, shallow, dished heads is investigated because of their extensive use. Also, an analysis of vessels for ultra-high pressure, employing thick-wall, multilayer, cascade, segmented, yoke, and wedge principles of design is presented. An introduction to steady-state and transient thermal stresses and their evaluation in terms of the full restraint thermal stress by analytical and graphical methods is given.

Chapter 3 covers the bending of flat, solid, circular plates under uniform and concentrated loading, and the effect of local flexibility at clamped-edge supports. Likewise, the design of stacked and built-up plates is developed and the design of orthogonal and concentric reinforced and perforated plates is analyzed together with expanded and welded tube-to-tubesheet joints. Expanded tube joints, wherein union is achieved through residual stress, are treated in depth. Not only is this the oldest and most widely used joining method, but it is the only one available for many pressure components employing unweldable dissimilar materials.

Chapter 4 presents the determination by the elastic foundation method of secondary bending and direct stresses encountered in vessels as a result of differential dilation of their parts. An analysis of bimetallic joints, frequently used in the chemical, petroleum and power industry, and their optimum location is developed. Likewise, an introduction to flange design is presented, together with a discussion of elastic foundation attenuation factors and their part in appraising the extent of secondary stresses and opening reinforcement limits in vessels.

Chapter 5 discusses the failure analysis and failure prevention of materials in their environment, for example, irradiation damage, hydrogen embrittlement, elevated and cryogenic temperatures, the multitudinous effects on fatigue life, etc. The economic trend to high strength materials, with their associated susceptibility to brittle fracture, has focused considerable attention to this subject. Applicable theories of failure and fracture mechanics analysis methods are presented to predict their behavior. This involves a basic understanding of the structure of metals and their elastic and plastic behavior. Fatigue is a prime cause of vessel failure, but it is completely amenable to prevention; accordingly, low and high cycle fatigue behavior, life prediction and damage accumulation are given together with a fatigue theory to account for multidirectional applied and residual stress conditions. High temperatures in the petroleum, chemical, and power industries have accentuated the problem of creep and rupture. Hence, life and strain fraction concepts for predicting service life, methods of estimating the relaxation of bolted joints, and the effect of the thermal stress relief of residual stresses in welded vessels to enhance safety are developed. Ways of establishing optimum metal forming temperatures for fabrication are presented, as are methods of evaluating material degradation at elevated temperatures. High temperatures can also produce opposite environmental effects; for instance, they increase the hydrogen embrittlement of petroleum processing vessels, while mitigating the neutron embrittlement of nuclear reactor vessels. All products have flaws which originate with the parent material, result from the fabrication method, or are designed-in by construction details. Hence it is important to appreciate this reality and appraise its significance for the intended service. In this respect, crack acceptance criteria, defect size evaluation, and design methods for attaining the required vessel life are discussed.

Chapter 6 covers design-construction features and their effect on geometric and thermally induced stress concentrations. Particular attention is given to those encountered under static and dynamic conditions at vessel openings, nozzles and structural supports and the means of coping with them to insure maximum integrity. The theory and practice of reinforced openings for radial, nonradial, and multiple nozzle arrangements are covered, as is designing their thermal sleeves which are vital to vessel thermal-shock protection. Stresses in bolts and the design of bolted and nonbolted closures receive extensive treatment as do the use of crack arrest features to negate brittle fracture potential. Vessel support skirts, saddles, and attachments impose both structural and thermal loadings that must be reconciled with the vessel pressure stresses. Gaskets are essential to removable closures and their type, design, and control parameters are presented. Thin claddings are widely used to prevent corrosion of the base metal or contamination of the media, and their life is appraised.

Chapter 7 introduces fabrication-construction methods and their economic potential. This includes novel innovations to satisfy a unique requirement, such as filament-wound, multilayer, wire-wrapped, link-belt, coiled, prestressed steel and concrete, and other vessels. Material selection is by basic cost per unit of stress and optimum safety factors utilizing advanced composites, high strength materials, or those with enhanced properties such as that obtained from directional solidification for use in a creep rupture environment. Fabrication methods like modular construction, cryogenic and high energy forming, adhesive joints, metallurgical bonding and healing of internal defects by hot isostatic pressing, etc. – all to achieve the economic goal of low cost and long service life – are presented.

Chapter 8 introduces the stability theory of plain and stiffened vessels, and its application to the design of thin, intermediate and thick walled ones. The overall stabilizing effect of structural stiffeners, as well as their effect in regions of high local compressive stress, is covered from initial design, failure analysis, and repair viewpoints. This forms the basis for the development of regulatory codes and compliance standards. The fabrication tolerances and construction details of noncircularity, local thinning, unreinforced openings, and stress concentrators are not self-limiting or self-compensating in a buckling phenomenon, and these critical effects are evaluated."

J. H. Harvey
(*from* Preface)

Pressure Vessel Design Handbook, Second Edition, 1985, by Henry H. Bednar, Van Nostrand Reinhold Company, New York, $46.50.

"This handbook has been prepared as a practical aid for engineers who are engaged in the design of pressure vessels. Design of pressure vessels has to be done in accord with specific codes which give the formulas and rules for satisfactory and safe construction of the main vessel components. However, the codes leave it up to the designer to choose what methods he will use to solve many design problems; in this way, he is not prevented from using the latest accepted engineering analytical procedures.

Efficiency in design work is based on many factors, including scientific training, sound engineering judgment, familiarity with empirical data, knowledge of design codes and standards, experience gained over the years, and available technical information. Much of the technical information currently used in the design of pressure vessels is scattered among many publications and is not available in the standard textbooks on the strength of materials.

In revising the first edition the intent has been to improve the handbook as a reference book by enlarging its scope. The stress analysis of pressure vessels has been greatly enhanced in accuracy by numerical methods. These methods represent a great addition to the analytical techniques available to a stress analyst. Therefore, chapter 12 describing the most important numerical methods with illustrative examples has been added. Throughout the text new material and new illustrative examples have also been added. The writer believes that any technical book in which the theory is not clarified by illustrative examples, can be of little use to a practicing designer engineer. Also some typographical errors have been corrected.

It is assumed that the reader has a working knowledge of the ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels, Division 1."

H. H. Bednar
(*from* Preface)

The Engineer Is Human, 1985, by Henry Petroski, St. Martin's Press, New York, $16.95.

"Though ours is an age of high technology, the essence of what engineering is and what engineers do is not common knowledge. Even the most elementary of principles upon which great bridges, jumbo jets, or super computers are built are alien concepts to many. This is so in part because engineering as a human endeavor is not yet integrated into our culture and intellectual tradition. And while educators are currently wrestling with the problem of introducing technology into conventional academic curricula, thus better preparing today's students for life in a world increasingly technological, there is as yet no consensus as to how technological literacy can best be achieved.

I believe, and I argue in this essay, that the ideas of engineering are in fact in our bones and part of our human nature and experience. Furthermore, I believe that an understanding and an appreciation of engineers and engineering can be gotten without an engineering or technical education. Thus I hope that the technologically uninitiated will come to read what I have written as an introduction to technology. Indeed, this book is my answer to the questions "What is engineering?" and "What do engineers do?"

The idea of design – of making something that has not existed before – is central to engineering, and I take design and engineering to be virtually synonymous for the purposes of my development. Examples from structural designs commonly associated with mechanical and civil engineers are most prominent in this book because it is from those fields that I draw my own experiences, but the underlying principles are no less applicable to other branches of engineering.

I believe that the concept of failure – mechanical and structural failure in the context of this discussion – is central to understanding engineering, for engineering design has as its first and foremost objective the obviation of failure. Thus the colossal disasters that do occur are ultimately failures of design, but the lessons learned from those disasters can do more to advance engineering knowledge than all the successful machines and structures in the world. Indeed, failures appear to be inevitable in the wake of prolonged success, which encourages lower margins of safety. Failures in turn lead to greater safety margins and, hence, new periods of success. To understand what engineering is and what engineers do is to understand how failures can happen and how they can contribute more than successes to advance technology."

H. Petroski
(*from* Preface)

Process Plant Layout, 1985, ed. by J. C. Mecklenburgh, Halsted Press/John Wiley and Sons, Inc., New York.

"Layout is concerned with the spatial arrangement of process plant and its interconnections, such as piping. Good