Book Review

PVP-57: Pressure Vessel Design

G. E. O. Widera, Editor

The papers in this special publication were presented at a two-session symposium entitled “Pressure Vessel Design,” held at the 1982 PVP Conference and Exhibition in Orlando, Florida. The purpose of the symposium was to present a broad spectrum of present activities in the area of pressure vessel design. A large number of experts were invited to discuss their current work. Such topical areas of ASME Code analysis and design, PVRC research, buckling analysis and design criteria, effect of manufacturing tolerances, high temperature and pressure design, and composite vessel construction were covered in the sessions and are detailed in this volume.

In the initial paper, J. R. Farr presents the background and development of design formulas and methods used to calculate the minimum required thickness of pressure vessel components according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and 2. Included is a review of some of the new procedures and design methods which have recently found their way into the Code. Much of this latter material is the result of work done by the Pressure Vessel Research Committee of the Welding Research Council. W. L. Greenstreet gives a brief description of programs now in progress in the PVRC Design Division. A sketch of the origin, purposes and organization of PVRC is also presented.

The premise of R. F. Reedy’s paper is that the design engineer’s role not be limited to design and analysis only. Since the engineer is the main link among the owner, fabricator, and constructor, the designer must become involved in material selection, fabrication details, selection of appropriate nondestructive examinations, and complete design control and verification to ensure that the final structure meets the design criteria.

The next group of papers involves the buckling of vessels and components. G. D. Galletly examines several codes dealing with the prevention of buckling in unstiffened cylindrical shells subjected to external pressure or axial load, or a combination of these loads. Often, the difference between theoretical and experimental predictions is due to the presence of initial imperfections. R. L. Citerly’s paper examines the applicability of ASME manufacturing tolerance guidelines to analysis requirements and presents a method of incorporating the tolerances in imperfection analyses. C. R. Steele and G. V. Ranjan performed a study to determine the effect of a ring stiffener attached at the knuckle region of a torispherical head on a cylindrical vessel on the critical pressure at which circumferential wrinkling occurs. They concluded that one or more discrete rings are not effective in increasing the critical pressure. In the final paper of this group, the Southwell method of prediction buckling loads is applied by L. H. Sobel to test results on elbows loaded by an in-plane closing bending moment. The major conclusion is that the method is valid for the components he examined and also for a certain broader class of elastic or plastic nonlinear buckling (geometric collapse) problems.

The effect of bends is introduced into a piping system by using the flexibility factor concept. R. Natarajan and S. Mirza present a finite element scheme with a doubly curved shell element which can account for variations in thickness. They show that for in-plane moment loading, a normal thickness variations has a significant effect on the flexibility factors for commonly used 90-deg bends.

Recently, a great deal of attention has been focused on vessels used in high-pressure applications. This generally involves a heavy wall or layered construction. H. C. Rauschenplat presents a discussion of multiwall construction, which is created by thermally shrinking individual cylinders over each other. This method of construction has been incorporated into Section VIII of the ASME Code. Fatigue failures in thick-walled pressure vessels can occur at the outside diameter as a result of machined discontinuities or of strengthening by the autofrettage process. J. A. Kapp and S. L. Pu present conservative estimates of fatigue life which can be useful in examining designs for failure by fatigue crack initiation. Often, several types of construction are proposed for a particular process, and in order to find the optimum one, a comparison study must be made. In the paper by T. R. Tauchert and D. C. Leigh, this is done for four alternative designs (single wall, total layered, prestressed concrete and prestressed cast iron) for a large diameter coal gasification reactor.

Reactor vessels for commercial-size LFMBR plants are quite large and necessarily thin-walled. They present the designer with problems in providing a balanced design to accommodate seismic, design basis accident and thermal loads. R. W. Seidensticker, et al., present a comprehensive set of scoping calculations in order to guide the vessel designer in subsequent design iterations. With reference to present day nuclear power plants, a problem of concern is the degradation of mechanical properties due to irradiation. The effect of the latter on the crack-arrest toughness of low-copper base plate steels is the topic of a paper by C. W. Marshall, et al. Their results indicate a modest temperature shift, in agreement with that observed in the Charpy V-notch impact energy curve and with that predicted by NRC Reg. Guide 1.99.

The last group of papers involves the application of structural plastics in pressure vessel construction. The lead-off paper is by G. E. O. Widera and D. L. Logan, who present a uniformly valid set of first approximation shell equations. These equations are applicable to cylindrically shaped vessels that have a construction which is anisotropic and nonhomogeneous in the thickness direction. Typical example calculations are given for laminated cylinders. S. G. Ladkany discusses analysis and design considerations for large high-performance, prestressed aluminum vessels which are circumferentially reinforced with fiberglass epoxy or pultruded polyester. The analysis includes prestressing pressure, stability of the stiffened aluminum liner, burst pressure and a controlled failure mode in the circumferential direction to improve the probability of a leak before burst condition.

U. Yuceoglu and D. Updike discuss the elasto-static interaction problem of two closely spaced initial delamination flaws in a multilayer pressurized cylindrical shell. They show the existence of an interaction length for the adhesive ligament beyond which no interaction occurs between the two flaws.

A. V. Singh, et al., report on the development of an annular finite element for the elastic analysis of sandwich shells. This analysis involves the use of an improved shell theory which takes into account the effects of rotatory inertia and transverse shear deformation. The annular finite element is shown to be a simple but powerful one from the point of view of computer time and accuracy of results.

1 Department of Mechanical Engineering, University of Illinois at Chicago, Chicago, III. 60607