Overview

The Symposium on Small Specimen Test Techniques and Their Application to Nuclear Reactor Vessel Thermal Annealing and Plant Life Extension may have marked a turning point in expanding the overall interest in ASTM Subcommittee E10.02 activities in radiation embrittlement for commercial power reactors. The symposium, which was held in New Orleans, Louisiana, on 29–31 Jan. 1992, was organized to bring together, in a single meeting, both the diverse interests and capabilities of the scientific testing community and the needs of the commercial light-water-cooled power-reactor industry. Participants came from all over the world with speakers from twelve countries presenting 40 papers covering three wide-ranging topics: (1) unique small and miniature specimens, as well as nondestructive, nonintrusive, and in-situ test techniques for measuring mechanical and fracture properties; (2) application of those techniques to assess irradiation-induced embrittlement; (3) actual examples of the use of these techniques to verify results of thermal annealing of vessels and to evaluate potential reactor-vessel life extension. The strong interest in the topics addressed at the symposium was apparently fueled by the maturing of miniature specimen testing technology and the simultaneous recognition of the very real need for continued and extended-life operation of installed nuclear reactor capacity, which amounts to many billions of dollars.

This symposium was the third in a related series of meetings on small specimen testing technology organized by ASTM Subcommittee E10.02 on Behavior and Use of Nuclear Structural Materials. The first was the Symposium on the Use of Small-Scale Specimens for Testing Irradiated Materials, which was held in Albuquerque, New Mexico in September 1983 and resulted in the publication of *The Use of Small-Scale Specimens for Testing Irradiated Materials, ASTM STP 888*. The primary driving force behind that symposium was the need of the fusion reactor materials research community to assess effects of the very high levels of irradiation expected in the first wall of a fusion reactor. The severely limited volume of materials which can be irradiated in test reactors to high levels of embrittlement results in the need for small specimen technology. The second meeting was a Workshop on Subsize Specimen Technology, held in New Orleans, Louisiana in January 1986 and sponsored jointly by ASTM Committees E10 on Nuclear Technology and Applications, E24 on Fracture Testing, and E28 on Mechanical Testing. The thrust of the workshop was to examine the needs for testing the relatively small sizes of material available to the irradiation effects research community and to compare those needs with the size requirements stipulated by existing testing standards. In contrast with the two earlier meetings, which focused exclusively on testing techniques, the recent symposium explicitly included the needs of and applications to commercial nuclear power reactors. In addition, the program of the recent symposium was strongly augmented by presentations of the continued development of testing technology within the fusion reactor research community. The final program of the symposium benefited significantly from the incorporation of numerous presentations from the International Energy Agency's planned workshop on small specimen test techniques, following an agreement to merge their workshop with the already-planned ASTM symposium. It is expected that the collection of the papers within this resulting special technical publication, which documents the recent symposium, will provide a resource for both researchers and end users in this field.

In the area of applications, a combination of Russian and Finnish authors provided an understanding of the usefulness of small specimen test techniques for commercial-nuclear-power plant-life extension. Their work described the application of small-specimen testing and sampling techniques to evaluate the potential for continued operation of various former eastern block pressurized-water-reactor pressure vessels.

In the sessions on nondestructive and nonintrusive testing techniques, novel approaches were described for obtaining materials information on thermal aging and embrittlement by electromagnetic and electrochemical techniques with little or no damage to the piece of material being sampled. A novel automated ball indentation technique was successfully applied to measure yield strength and flow properties in a range of metallic materials including welds and heat-affected zones and was further applied to nondestructively examine a structural component in situ (a circumferential weld in a stainless steel pipe). Application of these types of techniques will be very valuable in determining the degree of recovery following thermal annealing of nuclear pressure vessels.

Numerous novel and improved methods for obtaining and applying data from small specimens was described in the various sessions on testing techniques. Improvements in both correlation methods with standard-size specimens and test techniques were described by the authors of papers dealing with impact testing of subsize Charpy V-notch type specimens. The portion of the symposium related to fracture toughness provided new insight into both the limitations and possible ways to correct and utilize measurements made using very small fracture toughness specimens. Innovative experimental approaches to obtaining fracture toughness data with small amounts of test material included techniques for using very small-sized compact tension specimens as well as those describing radically new specimen designs. Improvements and innovations in some of the punch and disk testing, which had been described at the previous symposium on small-scale specimen testing in Albuquerque, were reported. New approaches for automating the remote testing and evaluating the preparation of irradiated tension specimens were described as well as new means of obtaining their required elongation information by techniques as sophisticated as laser interferometry.

As a result of the keen interest in and obvious applications for the small-specimen, nondestructive, nonintrusive, and in-situ testing techniques described at the meeting, it was agreed to initiate a follow-on activity with the explicit purpose of evaluating the type of materials property data generated by these various methods. ASTM Subcommittee E10.02 plans to coordinate such activities, which will include the distribution of one or more common sets of material for examination by interested parties. The eventual goal is to compare results from numerous nonstandard techniques with results from standardized tests and with each other. While this activity might eventually involve comparisons of material before and after irradiation, it is anticipated that the variations in materials properties, such as would result from irradiation-induced embrittlement, would initially be simulated (possibly by thermal treatments or cold work) to minimize handling of activated materials and to facilitate a much wider degree of participation in comparison testing.

Once the level of overall accuracy and the degree of reproducibility of data generated by the techniques described in this volume can be more fully evaluated among themselves and against other standardized tests, it will be possible to better ascertain and potentially improve the confidence of application of that data for integrity evaluations of reactor pressure vessels or any other structures. In the meantime, these testing techniques continue to provide a means of obtaining materials property information for situations where extraction of samples from vessels of other structural components is not desirable or possible and when the amount of available material is too limited to utilize conventional, standardized techniques.

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