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SMALL Specimen TEST Techniques

WILLIAM R. CORWIN

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ERIC VAN WALLE, EDITORS

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***Small Specimen
Test Techniques***

*William R. Corwin, Stan T. Rosinski,
and Eric van Walle, editors*

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Foreword

This publication, *Small Specimen Test Techniques*, contains papers presented at the symposium of the same name held in New Orleans, Louisiana, on 13-14 January 1997. The symposium was sponsored by ASTM Committee E-10 on Behavior and Use of Nuclear Structural Materials, in cooperation with the European Network on Aging Materials Evaluation and Studies (AMES) and the TC5 Technical Subcommittee on Dynamic Testing at Intermediate Strain Rates of the European Structural Integrity Society (ESIS). The symposium chairman was William R. Corwin, Oak Ridge National Laboratory.

Contents

Overview

vii

MINIATURE IMPACT TECHNIQUES

ASTM Cross-Comparison Exercise on Determination of Material Properties Through Miniature Sample Testing—STAN T. ROSINSKI AND WILLIAM R. CORWIN	3
Sub-Size Impact Testing: CISE Experience and the Activity of the ESIS TC5 Sub-Committee—ENRICO LUCON	15
Comparison of Results of Instrumental Charpy- and Mini-Charpy Tests with Different RPV-Steels—WOLFGANG BÖHME AND WINFRIED SCHMITT	32
Fracture Toughness Evaluation from Instrumented Sub-Size Charpy-Type Tests—HANS J. SCHINDLER AND MARTIN VEIDT	48
Characterization of Ductile Fracture Toughness Based on Subsize Charpy and Tensile Test Results—WINFRIED SCHMITT, HELI TALJA, WOLFGANG BÖHME, SABINE OESER, AND HORST STÖCKL	63
Effects of Ligament Size and Tensile Properties on the Fracture of Pressure Vessel Materials Under Impact Loading—SCOTT E. SIDENER, ARVIND S. KUMAR, AND MARGARET L. HAMILTON	82
Instrumented Impact Testing of Subsize Charpy V-Notch Specimens—JORG F. KALTHOFF AND MICHAEL GREGOR	98
Dependence of Ductile-Brittle Transition Behavior on the Size of Charpy Specimen and the Location of V-Notch in the HAZ of Welded A533B PVS—AKIHIKO KIMURA, TETSUYA SUZUKI, MORIO JINCHO, AND HIDEKI MATSUI	110
Analysis of Procedures for the Determination of the Yield Force (F_{gy}) for Instrumented Sub-Sized Charpy-V Specimens—HOWARD TAYLOR	123
Fracture Toughness Testing of Small and Standard Bending Specimens—DIETMAR KALKHOF AND KLAUS KROMPHOLZ	137
The Actual Properties of WWER-440 Reactor Pressure Vessel Materials Obtained by Impact Tests of Subsize Specimens Fabricated Out of Samples Taken from the RPV—YURI N. KOROLEV, ALEXANDER M. KRUYKOV, YURI A. NIKOLAEV, PAVEL A. PLATONOV, YAROSLAV I. SHTRONBAKH, REINHARD LANGER, CHRISTOF LEITZ, AND CLAUDE-YVES RIEG	145

FRACTURE TOUGHNESS TECHNIQUES

Small Specimen Testing Applied at Surveillance Extension—ERNŐ CZOBOLY, FERENC GILLEMOT, AND FERENC OSZWALD	163
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Fracture Toughness Test on Precracked Charpy Specimens in the Transition Range for Linde 80 Weld Metals— K. Y. HOUR AND K. K. YOON	173
The Applicability of Small and Ultra-Small Fracture Toughness Specimens for Material Characterization— M. VALO, T. PLANMAN, AND K. WALLIN	196
Fracture Toughness Measurements in the Transition Regime Using Small Size Samples— RACHID CHAOUADI	214
Use of Precracked Charpy and Smaller Specimens to Establish the Master Curve— M. A. SOKOLOV, D. E. MCCABE, Y. A. DAVIDOV, AND R. K. NANSTAD	238
On the Utilization of High Rate Pre-Cracked Charpy Test Results and the Master Curve to Obtain Accurate Lower Bound Toughness Predictions in the Ductile-to-Brittle Transition— JAMES A. JOYCE	253
Characterization by Notched and Precracked Charpy Tests of the In-Service Degradation of Reactor Pressure Vessel Steel Fracture Toughness— ALBERT FABRY	274
Developing Fracture Assessment Methods for Fusion Reactor Materials with Small Specimens— G. R. ODETTE, K. EDSINGER, G. E. LUCAS, AND E. DONAHUE	298
Using Small Cracked Round Bars to Measure the Fracture Toughness of a Pressure Vessel Steel Weldment: A Feasibility Study— JACQUES H. GIOVANOLA, R. W. KLOOP, J. E. CROCKER, D. J. ALEXANDER, W. R. CORWIN, AND R. K. NANSTAD	328
Estimation of Fracture Toughness Values for Titanium Alloy Using Small Centre Notched Round Specimens— DAVOOD SARCHAMY AND M. GEOFF BURNS	353
Fracture Toughness Derived from Small Circumferentially Cracked Bars— MARC SCIBETTA AND RACHID CHAOUADI	363

FRACTURE TOUGHNESS TECHNIQUES

Critical Analysis of Results from the ASTM Round-Robin on Reconstitution— KUNIO ONIZAWA, ERIC VAN WALLE, RANDY K. NANSTAD, MIKHAIL SOKOLOV, AND WAYNE PAVINICH	383
Comparison of Compact, Reconstituted and Subsize Charpy Specimens— ELISABETH KEIM, REINHARD LANGER, AND GEORG HOFMANN	411
Specimen Reconstitution Technique and Verification Testing for Charpy Size SENB Specimens— HANS W. VIEHRIG AND JUERGEN BOEHMERT	420
The Effects of the Configuration of a Weld-Reconstituted Compact Tension Specimen on Fracture Toughness Determination— FREDERICK DE BACKER AND FEDERICO GUTIÉRREZ-SOLANA	436
Reconstitution of Sub Charpy-Size V-Notched and Pre-Cracked Specimens— MATTI J. VALO	451

Reconstitution of Fracture Toughness Specimen for Surveillance Test— MINORU TOMIMATSU, SEIICHI KAWAGUCHI, AND MASATO IIDA	470
Reconstitution of Charpy Impact Specimens by Surface Activated Joining— YUTAKA NISHIYAMA, KIYOSHI FUKAYA, KUNIO ONIZAWA, MASAhide SUZUKI, TERUMI NAKAMURA, SHOICHIRO KAIHARA, AKIRA SATO, AND KAZUO YOSHIDA	484
 TENSILE AND PUNCH TECHNIQUES 	
Microspecimen Tensile Tests of A533-B Steel— WILLIAM N. SHARPE, JR., DAVID DANLEY, AND DAVID A. LAVAN	497
Evaluation of the Fracture Toughness of a C-MN Steel Using Small Notched Tensile Specimens— B. MARINI, S. CARASSOU, P. WIDENT, AND P. SOULAT	513
Miniature Shear Punch Test with On-Line Acoustic Emission Monitoring for Assessment of Mechanical Properties— K. V. KASIVISWANATHAN, S. K. HOTTA, C. K. MUKHOPADHYAY, AND BALDEV RAJ	523
The Use of a Small Punch Test Procedure to Determine Mechanical Properties— WILLIAM K. LEE, DONALD R. METZGER, ALEXANDER DONNER, AND OLEV E. LEPIK	539
Fracture and Tensile Properties of ASTM Cross-Comparison Exercise A 533B Steel by Small Punch Testing— JUDE R. FOULDS, MING WU, SANJEEV SRIVASTAV, AND CHARLES W. JEWETT	557
Effect of Specimen Thickness on the Tensile Deformation Properties of SA508 C1.3 Reactor Pressure Vessel Steel— THAK SANG BYUN, JOO HARK KIM, SE HWAN CHI, AND JUN HWA HONG	575
The Prediction of Fracture Toughness Properties from 3MM Diameter Punch Discs— WILLIAM GEARY AND JOHN T. DUTTON	588
Evaluation of Ductility of Zircaloy-2 Materials Using a Small Ellipsoidal- Shaped Punch— RANDY W. L. FONG AND CHRIS R. FRASER	602
The Use of Shear Punch Testing to Clarify the Consequences of Helium Production in the Deformation of Isotopically Tailored Ferritic Alloys— MARGARET L. HAMILTON, G. LUKE HANKIN, AND DAVID S. GELLES	614
Indexes	621

Overview

The Symposium on Small Specimen Test Techniques demonstrated the overall interest in ASTM Subcommittee E10.02 activities in radiation embrittlement for nuclear reactors. The symposium, which was held in New Orleans, Louisiana, on January 13-14, 1997, was organized to bring together, in a single meeting, the interests and capabilities of the scientific testing community and the needs of the commercial light-water-cooled power-reactor industry for improved methods to characterize component integrity. Technical interest in this topic was certainly demonstrated through the presentation of over 30 papers and 13 posters by experts representing 15 countries. A wide range of subjects was discussed during the symposium, concentrating on: (1) the use of unique small and miniature specimens, as well as nondestructive, nonintrusive, and in-situ test techniques for measuring mechanical and fracture properties; (2) the application of those test methods to assess irradiation-induced embrittlement; and (3) actual examples of the use of these test techniques for determining material integrity and to evaluate potential component life extension. The strong interest in the topics results from the desire to improve miniature specimen testing technology and the recognition of the potential benefits in commercial nuclear power plant operation through improved integrity assessment.

This symposium was the third in a series of ASTM symposia on small specimen testing technology organized by ASTM Subcommittee E10.02 on Behavior and Use of Nuclear Structural Materials. The first symposium was held in Albuquerque, New Mexico in September 1983 and is summarized in *The Use of Small-Scale Specimens for Testing Irradiated Materials*, ASTM STP 888. The primary driving force 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 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 symposium, held in New Orleans, Louisiana in January 1992, explicitly included the needs of and applications to commercial nuclear power reactors, with direct application of small specimen test techniques to reactor pressure vessel annealing and life extension and the continued development of testing technology within the fusion reactor research community. The symposium is documented in *Small Specimen Test Techniques Applied to Nuclear Reactor Vessel Thermal Annealing and Plant Life Extension*, ASTM STP 1204. As a result of this keen interest in and obvious applications for the diversity of small specimen testing techniques, ASTM Subcommittee E 10.02 initiated an international testing exercise in 1994 to obtain a cross-comparison of material property measurements obtained from various types of subsized-specimen testing techniques. Sixteen organizations representing 10 countries initially participated. Objectives were: (1) to benchmark various subsized specimen testing techniques by comparing testing results with established material properties for the material tested, and (2) to provide information to participants to improve the correlation of subsized specimen testing results with material properties determined through standard ASTM methods. A variety of miniature testing techniques were utilized by the participants during this exercise on selected pressure vessel steel.

The recent symposium focused on the experimental, analytical, and computational aspects of small (and miniature) specimen test techniques, as well as on application to component integrity assessment. In addition, results of the cross-comparison exercise were presented.

X SMALL SPECIMEN TEST TECHNIQUES

The collection of papers within this special technical publication will provide a resource for both researchers and end users in this field. The symposium was organized into sessions covering the following small specimen test techniques: (1) miniature impact, (2) fracture toughness, (3) precracked round bars, (4) reconstitution, and (5) tensile and punch. In addition, a poster session presented additional information in these areas.

Two separate presentations reviewed international testing programs to compare miniature specimen testing results and investigate the impact of testing variables on the prediction of component behavior. These activities included various types of miniature test techniques and involved different materials and test conditions in order to provide a better understanding of small specimen behavior when compared to results obtained from standard ASTM specimen configurations.

Numerous novel and improved methods for obtaining and applying data from small specimens were 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 impact of critical parameters in the reconstitution process, including welding technique, insert size, specimen orientation, and even striker tup geometry, were addressed. The potential for utilizing reconstituted Charpy samples on component integrity was discussed in view of future, enhanced surveillance methodologies for plant life management. The portion of the symposium related to fracture toughness provided new insight into both the potential 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 new specimen designs. Of particular interest during this symposium was the application of the Master Curve method being standardized under ASTM Committee E 08 on Fatigue and Fracture for the determination of reference temperature in the transition region for ferritic materials. This technique may significantly enhance the assessment of reactor pressure vessel integrity, and several papers demonstrating application of the Master Curve approach were presented. A new addition to this symposium series was the feasibility of using small fatigue-precracked round bars to measure fracture toughness of pressure vessel materials and to refine and validate experiment and analysis procedures. Improvements and innovations in several of the punch and disk testing techniques, discussed in previous meetings in this series, were also reported.

As the level of overall accuracy and the degree of reproducibility of data generated by the small specimen test techniques improves, the techniques can be more fully evaluated among themselves and against other standardized tests. This analysis will ultimately improve the confidence regarding application of these techniques for the evaluation of reactor pressure vessels or any other structures. It is apparent from the papers presented in this symposium, and the technical information presented throughout this symposium series, that these testing techniques continue to mature. They provide a means of obtaining material property information for situations where extraction of samples from vessels or other structural components is not desirable or possible, or when the amount of available materials is too limited to utilize conventional, standardized techniques.

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