Pendulum Impact Machines

Procedures and Specimens for Verification

Thomas A. Siewert and
A. Karl Schmieder, editors

STP 1248

STP 1248

Pendulum Impact Machines: Procedures and Specimens for Verification

Thomas A. Siewert and A. Karl Schmieder, Editors

ASTM Publication Code Number (PCN):
04-012480-23

ASTM
1916 Race Street
Philadelphia, PA 19103
Printed in the U.S.A.

Library of Congress Cataloging-in-Publication Data

Pendulum impact machines: procedures and specimens
for verification/Thomas A. Siewert and A. Karl
Schmieder, editors.
p. cm.--(STP; 1248)
"ASTM publication code number (PCN): 04-012480-23"
Includes bibliographical references and index.
ISBN 0-8031-2018-4
1. Impact--Testing--Equipment and supplies. 2.
Pendulum. 3. Notched bar testing--Equipment and
supplies. I. Siewert, T. A. II. Schmieder, A. Karl
(Albert Karl), 1919-- . III. Series: ASTM special
technical publication; 1248.
TA418.34.P46 1995
620.1'123--dc20

95-13999
CIP

Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

Printed in Fredericksburg, VA
May 1995

Foreword

This publication, *Pendulum Impact Machines: Procedures and Specimens for Verification,* contains papers presented at the symposium of the same name held in Montreal, Quebec, Canada, on 18–19 May 1994. The symposium was sponsored by ASTM Committee E-28 on Mechanical Testing and its Subcommittee E28.07 on Impact Testing. The symposium was chaired by Tom Siewert, National Institute of Standards and Technology, and Karl Schmieder, consultant on mechanical testing.

Contents

Overview vii

THE SPECIMEN

The Role of Strike Marks on the Reproducibility of Charpy Impact Test Results—A. KARL SCHMIEDER, PATRICK T. PURTSCHER, AND DANIEL P. VIGLIOTTI 003

Effect of Squareness Tolerance on Charpy V-Notch Impact Energy—FRANCIS J. MARSH 019

The Production of Calibration Specimens for Impact Testing of Subsize Charpy Specimens—DAVID J. ALEXANDER, WILLIAM R. CORWIN, AND THOMAS D. OWINGS 032

Miniaturized Notch Test Specimen and Test Machine Design—MICHAEL P. MANAHAN, SR., RANDALL B. STONESIFER, YANG SOONG, AND JAMES M. BURGER 039

The Optimization of Insert Size for Reconstituting Previously Tested Charpy Specimens—JAMES F. WILLIAMS, REGIS P. SHOGAN, AND LEO ALBERTIN 070

THE ANVILS AND THE STRIKER

Effect of Surface Finish of Charpy Anvils and Striking Bits on Absorbed Energy—EARL A. RUTH, DANIEL P. VIGLIOTTI, AND THOMAS A. SIEWERT 091

Striker Geometry and Its Effect on Absorbed Energy—EARL A. RUTH 101

Charpy Impact Test Results on Five Materials and NIST Verification Specimens Using Instrumented 2-mm and 8-mm Strikers—RANDY K. NANSTAD AND MIKHAIL A. SOKOLOV 111

The Effect of Charpy V-Notch Striker Radii on the Absorbed Energy—THOMAS A. SIEWERT AND DANIEL P. VIGLIOTTI 140

Effects of the Striking Edge Radius and Asymmetrical Strikes on Charpy Impact Test Results—MEGUMU TANAKA, YOSHINOBU OHNO, HIDEKAZU HORIGOME, HIROSHI TANI, KENICHIRO SHIOTA, AND AKINORI MISAWA 153

ESTABLISHING REFERENCE ENERGIES

Production of Charpy Impact Verification Specimens and Verification of Machine Performance—NAMITERU HIDA 171

Proposed Changes to Charpy V-Notch Machine Certification Requirements—JOLENE D. SPLETT AND JACK C.-M. WANG 182

Presentation of the French Supply of Charpy V Reference Test Pieces—GERARD GALBAN, IVAN LE MUET, DENIS MOUGIN, GILBERT REVISE, ROGER ROCHE, AND LOUIS ROESCH 195

TESTING PROCEDURES AND OTHER TOPICS

Correction of Charpy Impact Values for Kinetic Energy of Test Specimens—RAJESH G. CHANDAVALE AND TAMAL DUTTA 221

Load Damping Absorbers and the Determination of Load/Displacemnt Data for Precracked Charpy Specimens—KEN J. KARISALLEN AND JAMES R. MATTHEWS 232

Low Cost Lower Bound Toughness Measurements—CHRISTOPHER N. MCCOWAN, JAMES W. DALLY, DANIEL P. VIGLIOTTI, AND OUK S. LEE 246

Design and Evaluation of a Verification System for Force Measurements Using Instrumented Impact Testing Machines—THOMAS J. MACKIN AND DAVID F. TOGNARELLI 268

Instrumented Impact Testing of Polymeric Materials—JÖRG F. KALTHOFF AND GERD WILDE 283

Indexes 295

Overview

This was the sixth symposium published by ASTM on the topic of impact testing. The five previous symposia, *Proceedings of ASTM,* Vol. 22-II (1922), *Proceedings of ASTM,* Vol. 38-II (1938), STP 176 (1956), STP 466 (1970), and STP 1072 (1990), were sponsored by ASTM Subcommittee E28.07 (prior to 1969 known as E-1.7). These symposia covered a broad range of topics and occurred rather infrequently. The period before 1985 might be characterized as one in which the Charpy test procedure was broadly accepted and changing very slowly. However, the last symposium (1989), "Charpy Impact Test: Factors and Variables," was driven by new forces: a recognition within ISO Technical Committee 164 (Mechanical Testing) Subcommittee 4 (Fracture) of shortcomings in the procedure and a desire to know the basis for the requirements. Although most of the requirements and procedure details were considered quite reasonable and still valid, there was a desire by the late 1980s to restudy a few of the relationships. Some felt that changes in materials and energy ranges (from those under which the original relationships were developed) might justify slight revisions to the procedures. Also, some other standards and users in other countries had adopted different procedures, which raised questions about comparison of data developed under these different procedures.

Authors from five countries presented a broad variety of test data at the 1989 Symposium, which encouraged spirited discussion and comparison of the results. The twelve papers in the proceedings (STP 1072) and another paper in the *Journal of Testing and Evaluation* provided a review of the effects of procedural and specimen variables in Charpy impact testing. The data proved to be of interest to many general users of the test, but was of particular interest to the members of ASTM Subcommittee E28.07 (the subcommittee responsible for Standard E-23 on the Charpy test). During the past five years, the data presented at the symposium have been the single most important factor in determining whether to change various requirements in Standard E-23. The data have also been useful in supporting tolerances and procedural details during the reballoting of ISO Standard 442 on Charpy testing.

By 1991, the E28 Subcommittee on Symposia suggested that it was time to schedule another symposium on Charpy impact testing. One reason was because the 1989 symposium did not answer certain questions about the choice of tolerances in the specifications. Indeed, several of the papers appeared to reach conflicting conclusions about the effect of certain variables.

The Call for Papers for the 1994 Symposium specifically invited studies on the issues of procedures and specimens for machine verification. The following paragraphs describe our success in attracting papers that study the procedural details and suggest changes in the tolerances in ASTM and ISO standards.

This publication includes three papers comparing the 8-mm and the 2-mm radius striker designs. These papers (Nanstad and Sokolov; Siewert and Vigliotti; and Tanaka et al.) confirm that the data taken with the two strikers are not interchangeable and suggest that the 8-mm radius typically produces higher energies below about 20 J and that the 2-mm radius striker produces higher energies above 100 J. In the intermediate range, the results are less consistent. During the final discussion period, we tried to find ways to resolve the use of different striker radii between countries. It became clear that there is no easy solution because each country has developed a large statistical database with their own striker design (8- or 2-mm radius). These data have been incorporated in a complex web of other standards and requirements. However, it was very encouraging to learn that the European standards (EN series) may add the 8-mm striker in the next revision (in about four years) and that the ASTM subcommittee plans to add the 2-mm striker in their next revision of E23. Unfortunately, there does not seem to be a similar activity in Japan.

We heard about the development of standardized specimens for indirect verification of machine performance to supplement direct measurements (primary physical characteristics of the machines). Papers by Hida and by Galban et al. described the development of standardized specimens for Japan and France, respectively. Building on the statistical calculations contained in these two papers, a paper by Splett and Wang provided more details on the determination of the quality of standardized specimens.

In the area of machine and specimen tolerances, we learned about the effect of machine alignment on second strike marks (Schmieder et al.), the effect of specimen edge squareness (Marsh), striker geometry tolerances (Ruth), striker surface finish (Ruth et al.), subsize speciments (Alexander et al. and Manahan et al.), and reconstitution of specimens (Williams et al.).

The topic of machine verification is becoming important for nonmetallic materials as well. The Call for Papers was developed in discussions with ASTM Subcommittee D20.10 (Mechanical Properties of Plastics) and Section D20.10.02 (Impact Properties of Plastics) to include papers on Charpy and Izod testing of plastics. We received a paper by Mackin and Tognarelli on calibration of an impact machine for plastics and one by Kalthoff and Wilde on instrumented impact testing of polymeric materials.

Other papers covered the use of load-displacement curves for obtaining more information from impact tests (KarisAllen and Matthews and McCowan et al.) and the kinetic energy of the specimen being tossed from the machines (Chandavale and Dutta for an unbroken specimen; Kalthoff and Wilde for the two broken halves).

Many people commented that they found the information presented in this symposium to be particularly interesting. One reason for this may be that the 1994 symposium attracted contributions from many countries. Twenty-one of the forty-two authors and coauthors are from outside the U.S., an even broader participation that in the 1989 symposium. We believe that this is due partly to wide distribution of the Call for Papers at international meetings and because of the current importance of this topic in international commerce.

Although the 1994 symposium provided much useful information that will allow us to improve impact testing standards, it also identified other differences between standards and will require further study before a decision can be made. The following topics should be considered for inclusion in the Call for Papers for a future symposium:

1. The theoretical effect of striker contact radius on the state of elastic stress at or near the root of a Charpy specimen notch.
2. The use of instrumented strikers to separate the energies of crack initiation and of crack propagation for machines with 8-mm and 2-mm striker radii in the range below 25 J Charpy V-notch absorbed energy.
3. Correlation of results of static tests for plane-strain fracture toughness to those for Charpy V-notch impact tests at different temperatures, using both the ISO and the ASTM striker.
4. By finite element or other analytical techniques, determine the striker form that will minimize the plastic work of crushing and bending the specimen.
5. Compare the absorbed energy as measured by machines with C-type pendulums to U-type, including materials with high yield strength and absorbed energy less than 20 J.

Acknowledgments

We appreciate the assistance of E28.07 members, many of whom helped by chairing the sessions and by reviewing the manuscripts. We particularly appreciate the assistance of J. M. Holt who (in his role and Chairman of Subcommittee E28.93 on Symposia) helped us obtain sponsorship of the Symposium and provided valuable advice on the arrangements, and who (in his role as the U.S. delegate to ISO Committee 164-TC4) encouraged international participation. We also received wise advice from a large number of the ASTM staff on symposium arrangements, selection of reviewers, and the other myraid of details necessary for a successful symposium.

ISBN 0-8031-2018-4