
STEEL FORGINGS

Nisbett / Melilli editors



STP 903

STEEL FORGINGS

A symposium
sponsored by
ASTM Committee A-1
on Steel, Stainless Steel,
and Related Alloys
Williamsburg, VA, 28–30 Nov. 1984

ASTM SPECIAL TECHNICAL PUBLICATION 903
Edward G. Nisbett, National Forge Co.,
and Albert S. Melilli, General Electric,
editors

ASTM Publication Code Number (PCN)
04-903000-02



AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race Street, Philadelphia, PA 19103

Library of Congress Cataloging-in-Publication Data

Steel forgings.

(ASTM special technical publication; 903)

Includes bibliographies and index.

“ASTM publication code number (PCN) 04-903000-02.”

1. Steel forgings—Congresses. I. Nisbett, E. G. (Edward G.). II. Melilli, Albert S. III. American Society for Testing and Materials. Committee A-1 on Steel. IV. Series. TS320.S745 1986 672.3'32 86-14066
ISBN 0-8031-0465-0

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1986

Library of Congress Catalog Card Number: 86-14066

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Printed in Ann Arbor, MI
September 1986

Foreword

The symposium on Steel Forgings was held in Williamsburg, Virginia on 28–30 Nov. 1984. The American Society for Testing and Materials' Committee A01 sponsored the symposium. E. G. Nisbett, National Forge Co., and Albert S. Melilli, General Electric, served as cochairmen of the symposium and as coeditors of this publication.

Related ASTM Publications

Through-Thickness Tension Testing of Steel, STP 794 (1983), 04-794000-02

Rolling Contact Fatigue Testing of Bearing Steels, STP 771 (1982), 04-771000-02

Application of 2-1/4Cr-1Mo Steel for Thick-Wall Pressure Vessels, STP 775 (1982), 04-755000-02

Toughness of Ferritic Stainless Steels, STP 706 (1978), 04-706000-02

Properties of Austenitic Stainless Steels and Their Weld Metals (Influence of Slight Chemistry Variations), STP 679 (1979), 04-679000-02

A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

ASTM Committee on Publications

ASTM Editorial Staff

David D. Jones
Janet R. Schroeder
Kathleen A. Greene
Bill Benzing

Contents

Overview	1
-----------------	---

TURBINE AND GENERATOR FORGINGS

Keynote Address

The Development of Improved Forgings for Modern Steam Turbines—R. M. CURRAN	9
--	---

Steel Production for Rotors

Influence of Advanced Steelmaking Technology on Specification Trends for Rotor Forgings—J. E. STEINER AND R. I. JAFFEE	35
Discussion	43

The Effect of Alloying Elements and Steelmaking Processes on the “A” Segregation Occurrence in Large Ingots—J. T. KIM, M. R. PYO, Y. S. CHANG, AND H. S. CHIANG	45
--	----

Rotor Manufacture

Development of Integral High-Pressure–Low-Pressure Combination Rotor Forgings—M. YAMADA, M. MIYAZAKI, O. WATANABE, AND M. KAWAI	59
Discussion	71

Manufacture of Differentially Heat-Treated Turbine Rotor Forgings—A. SUZUKI, S. KINOSHITA, AND H. KIKUCHI	74
Discussion	85

Manufacturing of Welded Polyblock Turbine Rotors for Pressurized Water Reactor Nuclear Plants; Optimization of the Steel Grade; Effect of Impurities—J. PISSELOUP, I. S. POITRAULT, A. DE BADEREAU, AND P. G. BOCQUET	87
Discussion	102

Steels for Rotors

**New 2Cr-Mo-Ni-W-V Steel for High-Pressure Rotors—H. FINKLER
AND E. POTTHAST** 107

**Mechanical Properties of Advanced Technology 1Cr-Mo-V Steam
Turbine Rotor Forgings—V. P. SWAMINATHAN, R. I. JAFFEE,
AND J. E. STEINER** 124
Discussion 141

**Soft-Martensitic Stainless Cr-Ni-Mo Steel for Turbine Rotors in
Geothermic Power Stations—K. SCHÖNFELD AND E. POTTHAST** 143
Discussion 154

Rotor Assessment

**Metallurgical Analysis of Flaws in Carbon-Molybdenum and Nickel-
Molybdenum-Vanadium Turbine Rotor Forgings—S. TONEY,
W. KIM, A. S. MELILLI, AND S. G. LEONE** 157
Discussion 177

**The Fracture Toughness of Actual and Simulated Large Rotor
Forgings Made from 3.5Ni Steel—J. ALBRECHT,
J.-E. BERTILSSON, AND B. SCARLIN** 178
Discussion 196

**Integrity of Full-Integral, Low-Pressure Nuclear Turbine
Forgings—S. KAWAGUCHI, N. KANNO, T. IWADATE, AND
T. OHHASHI** 203
Discussion 214

**In-Service Inspection Test and Evaluation Techniques for Large
Generator Rotors—R. H. BELLOWS, R. J. ZAWOYSKY, AND
D. N. WALKER** 219
Discussion 234

Generator Retaining Rings

**The Development of New Materials for Nonmagnetizable Retaining
Rings and Other Applications in the Power Generating
Industry—G. STEIN** 237
Discussion 256

18-18 Corrosion-Resistant Retaining Rings for Nuclear Power Plant Generators —J. B. RAMBAUD AND R. H. CAZENAVE	258
Discussion	272

PRESSURE VESSEL AND NUCLEAR FORGINGS

Review

Seamless Shell Course Forgings for Heavy-Wall Reactor Vessels: A Forgemaster's Critical Review —P. BERNABEL, L. CALLEGARI, M. SCEPI, AND T. SALINETTI	275
--	-----

Steels for Pressure Retaining Components

Evaluation of Modified 9Cr-1Mo Steel Forging —A. K. KHARE AND V. K. SIKKA	303
Discussion	327

Evaluation of the Modified 9Cr-1Mo Steel Forging by French Laboratories —A. GELPI	328
Discussion	345

Optimizing Mechanical Properties of Specialty, Stainless, and Heat-Resistant Alloy Steel Forgings by Thermomechanical Processing —G. W. KUHLMAN, R. PISHKO, W. S. DARDEN, AND W. L. KRUBSACK	346
Discussion	362

Forging Processing for Pressure Vessel and Nuclear Application

Application of New Types of Ingots to the Manufacturing of Heavy Pressure Vessel Forgings —P. G. BOCQUET, J.-C. SAINT-IGNAN, AND R. P. BLONDEAU	367
--	-----

Integral Forged Pump Casing for the Primary Coolant Circuit of a Nuclear Reactor: Development in Design, Forging Technology, and Material —W. AUSTEL AND H. KÖRBE	385
--	-----

Manufacturing of Large and Integral-Type Steel Forgings for Nuclear Steam Supply System Components —S. KAWAGUCHI, H. TSUKADA, K. SUZUKI, I. SATO, AND S. ONODERA	398
---	-----

Advanced Technology of Heavy-Section Tube Sheets for Nuclear Power Generation—T. A. SKAMLETZ AND W. W. GRIMM 410
Discussion 423

Best Possible Heat Treatment of Steel SA 336 F22 for the Production of Forged Shells with Heavy Walls—J. P. BADEAU, I. S. POITRAULT, A. DE BADEREAU, AND R. P. BLONDEAU 425
Discussion 438

Production of a 304 Stainless Steel Nuclear Reactor Forging from a Very Large Electroslag Refined Ingot—E. J. WATKINS AND E. L. TIHANSKY 439
Discussion 449

GENERAL INDUSTRIAL FORGINGS

Equipment and Forging Process

Survey of New Developments in Forging Techniques and Equipment—N. M. KRAMAROW 453

Forging Force Requirements with Special Regard to Shear Resistance of the Forge Material—L. J. JAVORIK 476

Forging of Long-Stroke Crankshafts by the TR Method—T. RUT 504

Manufacture and Application

Cryogenic Mechanical Properties of A286 Alloy and 304LN Stainless Steel Used in Fabrication of Support Struts for Superconducting Magnets—T. ABE, M. KOHNO, A. SUZUKI, AND R. M. SCANLAN 523
Discussion 539

Steel Forgings for a Tension Leg Platform Anchoring System—The Design and Management Contractor's Experience of Their Manufacture and Testing—P. J. WHITEHOUSE 540
Discussion 548

Test Methods and Forging Assessment

High-Sensitivity, Immersion, Ultrasonic Testing of Steel Forgings—J. G. GENSURE, A. S. MELILLI, AND S. M. BRUEGGEMANN 553

Hydrogen—Its Occurrence, Determination, and Control in Steel	
Forgings—E. L. MURPHY AND J. E. STEINER	573
Discussion	582
Failure Analysis of Hot Forging Dies—R. EBARA AND K. KUBOTA	583
Author Index	593
Subject Index	595

ISBN 0-8031-0465-0