

The 40th Anniversary Event of the Foundation of JSNDI

**NONDESTRUCTIVE TESTING &
STRESS-STRAIN MEASUREMENT,
FENDT '92**

**Volume II
Stress-Strain Measurement**

October 12-14, 1992

Tokyo, Japan

Edited by

T. KISHI

S. TAKAHASHI

**THE JAPANESE SOCIETY FOR NON-DESTRUCTIVE INSPECTION
(JSNDI)**

The 40th Anniversary Event of
the Foundation of JSNDI

**NONDESTRUCTIVE TESTING &
STRESS-STRAIN MEASUREMENT,
FENDT '92
(NDT&SSM, FENDT'92)**

Proceedings of
International Symposium on Nondestructive Testing &
Stress-Strain Measurement, FENDT'92
October 12-14, 1992
Tokyo, Japan

Volume II Stress-Strain Measurement

Edited by

T. Kishi and S. Takahashi

ORGANIZED
BY
THE JAPANESE SOCIETY FOR NON-DESTRUCTIVE TESTING
(JSNDI)

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system, without permission in writing from the publisher.

ISBN: 4-931018-02-5

Proceedings of International Symposium
on Nondestructive Testing
& Stress-Strain Measurement,
FENDT'92 (NDT&SSM, FENDT'92)
held in Tokyo, Japan, in October 12-14, 1992

Published by
THE JAPANESE SOCIETY FOR NON-DESTRUCTIVE INSPECTION

Printed in Japan

Organization

Paper Committee

T. Kishi	University of Tokyo (Japan)
S. Takahashi	Kanto Gakuin University (Japan)
K. Egawa	National Aerospace Laboratory (Japan)
H. Hoshikawa	Nihon University (Japan)
E. Isono	The Japanese Association for Promotion of NDT (Japan)
M. Kanbe	Fuji Electric Co. Ltd. (Japan)
H. Kato	Saitama University (Japan)
A. Maruyama	The Japan Welding Structure College (Japan)
H. Yoneyama	Ishikawajima-Harima Heavy Industries Co. Ltd. (Japan)

Organizing Committee

E. Yamamoto	Hiroshima Denki Institute of Technology (Japan)
K. Imoto	Meiji University (Japan)
S. Takahashi	Kanto Gakuin University (Japan)
N. Ooka	Japan Atomic Energy Research Institute (Japan)

FENDT '92 Steering Committee

M. Takagi	University of Tokyo (Japan)
H. Lee	Korean Society for Nondestructive Testing (Korea)
K.-C. Liu	The Republic of China's Society for Nondestructive Testing (China)

Secretariat

K. Egawa	National Aerospace Laboratory (Japan)
N. Ooka	Japan Atomic Energy Research Institute (Japan)
H. Daido	Du Pont Japan Ltd. (Japan)
Y. Igarashi	The Japanese Society for Non-Destructive Inspection (Japan)

VOLUME II: TABLE OF CONTENT

Plenary Lecture II

A Survey of Recent Stress-Strain Measurement in Japan	367
S. Takahashi	

TS5: X-Ray Stress Analysis I

Variation of X-Ray Parameters during Plane Bending Fatigue and Sliding Wear Processes in TiN Coated Carbon Steels	383
T. Endoh, K. Idemitsu and M. Kawakami	
X-Ray Stress Measurement of Laminated Plasma Spray Coating Layers	390
M. Nishida, T. Hanabusa and H. Fujiwara	
Determination of Stress Distribution in the Direction of Depth for Thin Films by Means of X-Rays	398
T. Sasaki, M. Kuramoto and Y. Yoshioka	

TS6: X-Ray Stress Analysis II

X-Ray Measurement of Residual Stress of TiC Coatings by CVD Method	404
K. Tanaka and M. Matsui	
X-Ray Measurement of Residual Stress in CVD Coating of TiC-SiC Composite	412
K. Suzuki and K. Tanaka	
X-Ray Stress Measurement of Sialon Ceramics	418
M. Kurita and A. Saito	

TS7: Photoelasticity I

Variation of Mixed-Mode Thermal Stress Intensity Factors of Plates with an Edge Crack	426
E. Matsumoto, H. Fujiwara, A. Saito and Y. Miyanishi	
Photoelastic Measurements of Thermal Stress in Adhesive Butt Joints	432
F. Nakagawa, T. Sawa and Y. Nakano	

Stress Concentration of Square Plates with a Rounded Square Hole Subjected to Internal Pressure	439
H. Fukusumi, H. Fujiwara, E. Matsumoto and A. Saito	

Determination of Stress Intensity Factors of Thick Cylinder with Cracked Inner Surface by Photoelastic Method	445
T. Aoki, M. Ishida and S. Takahashi	

TS8: Photoelasticity II

Automatic Whole-Field Measurement of Principal Axes from Photoelastic Experiment	453
E. Umezaki, H. Watanabe, A. Shimamoto and S. Takahashi	

Stress Freezing Analysis of the Fork-Type Dovetail of Steam Turbine Blade Roots	461
Y. Sawa, T. Yamasawa, K. Ikeuchi and M. Katayose	

Application of Orthotropic Photoelastic Coating Method to Stress Distributions Single Pin-Loaded Composite Plates	469
D.Z. Chen and W.J. Yu	

TS18: NDT of Concrete

In-Situ Test Methods Assessing the Quality of the Surface Layer of Concrete	477
Y. Tsukinaga, M. Shoya and Y. Kasai	

Testing Methods for Permeability and Cement Content of Structural Concrete	485
N. Yuasa, I. Matsui and Y. Kasai	

High Strain-Rate Testing of High-Strength Aluminum Alloys: Tension and Compression	493
T. Yokoyama	

TS19: X-Ray Stress Anlaysis III

X-Ray Study on Deformation Layer of Aluminum Alloy A5083 of Cutting Surface Using Water Jet	500
M. Katoh, K. Nishio, M. Abe and S. Mukae	

Study on Stress Corrosion Cracking in Austenitic Stainless Steel Welded Joint due to Weld Bead, Spatter and Arc Strike	509
M. Iwata, Y. Fujimoto, D. Achirudin and M. Kanetoshi	
Dependence of Substrate and its Temperature on Residual Stress Development in AlN Films Deposited on Glasses by Magnetron Sputtering Method	516
T. Hanabusa, K. Kusaka, K. Tominaga and H. Fujiwara	
Measurement of Residual Stress in Cold Rolled Steel Plates Using a Magnetic Anisotropy Sensor	524
H. Wakiwaka, K. Kondo, T. Umezawa Y. Nagasawa, S. Uchiyama and H. Yamada	
TS20: X-Ray Stress Analysis and Other Methods	
X-Ray Measurement of Stress in a Localized Area	531
Y. Yoshioka and S. Ohya	
Residual Stresses in Irradiated Zry-2 Cladding	537
C.H. Ho, J.J. Yeh, C.W. Yang and L.F. Lin	
X-ray Stress Measurements in the Surface Layer of the Hard-Machinable Materials Machined by TCAC Method	544
D. Senczyk and J. Brukwicki	
Cybernetical Model and Metrological Characterization of X-Ray Stress Methods	550
D. Senczyk	
TS21: Stress Strain Analysis – Caustics I	
Analysis of the Dynamic Fracture Behavior of Zirconium Ceramics up to 1200°C by the Caustic Method	556
M. Suetsugu, K. Shimizu and S. Takahashi	
Application of the Method of Caustics to Evaluating Stress Intensity Factors of Interface Cracks in Bonded Materials	564
K. Sato, Y. Aoyagi and Q.P. Hu	
Determination of Stress Intensity Factor for Orthotropic Material	572
G. So and S. Takahashi	

TS22: Stress Strain Analysis – Caustics II

Three Dimensional Shape Measurement Using Stereoscopy and Image Correlation Method	582
T. Mihara, H. Sumitomo, T. Furukawa and K. Date	
Application of the Method of Caustics to Anisotropic Materials	590
M.C. Baik, J.S. Hawong and S.H. Choi	
Application of the Optical Method of Caustics to Fatigue Crack Growth	598
S. Güngör, I.R. Wallhead and L. Edwards	

TS23: Stress Strain Analysis – Grid and Other Methods

Strain Measurement by Laser Diffraction Using High Frequency Grating	604
Y. Ma and M. Kurita	
Small Displacement Measurement by Phase-Shift-Method and Fourier-Transform-Moire-and-Grid-Method	611
Y. Morimoto and M. Fujisawa	
Holographic Measurement of the Deformation Patterns of Rectangular Billets Subjected to Upset Forging	617
M.A. Younes and M.H.M. Ahmed	
The Deformation in Systems Metal-Hydrogen and Metal-Deuterium at the Phase Transformation	625
L.V. Spivak and Y.I. Ragozin	

TS29: Fatigue and Dynamic Behaviors I

Study on Impact-Tensile Strength of Heat Sealing in Laminated Film Used for Liquid Package Bag (Effect of Material Change of Base Film)	632
K. Futase, A. Shimamoto, S. Takahashi and H. Aoki	
Exact Transient Analysis of a Subsurface Inclined Crack Subjected to Dynamic Impact Loadings	638
C.C. Ma and S.K. Chen	
Detection of Rolling Contact Fatigue by Measuring Development of Texture	648
Y. Inoue	

TS30: Fatigue and Dynamic Behaviors II

Effect Produced by Laser Heating on Fatigue Strength and Behaviour of Fatigue Cracks	654
V.A. Boguslayev, N.I. Obodan and F.P. Banas	
Crack Growth Behaviour in a Iron Base Superalloy under Creep, Fatigue and Creep-Fatigue Conditions	660
M.F. Geng and G.H. Zhou	

TS31: Stress Strain Analysis – Strain Gage

Strain Gage Method for Determining the Stress Intensity Factor of a Crack in a Strip Subjected to Transverse Bending	666
S. Kurosaki and S. Fukuda	
Strain Measurement on CFRP-FW Cylinder as a Structural Member of Space Structure	674
K. Egawa	
The Strength of Joints Combining Adhesives with Tap Bolts (The Cases Where Adherends are Hollow Cylinders and Rectangular T-Shape Flanges)	681
T. Sawa, S. Watanabe, K. Mutoh and T. Komatsu	
Determination of Stress Field on Gears with Defects in Tooth Root	689
J. Flašker and B. Aberšek	

TS32: Stress Strain Analysis – Electroplating and Barkhausen Method

An Application of Computer Image-Processing and Film Replica Technique to the Copper Electroplating Method of Stress Analysis	696
M. Sugiura and M. Seika	
Stress Measurement of Pearlitic Steel Ropes by Barkhausen Noise	704
M. Moilanen, R. Rautioaho, J. Kivimaa and H. Zhang	
The Image Processing and the Principles of Optimizing the Barkhausen Noise Parameters for Stress Measurements	711
V.L. Vengrinovich and A.L. Vishnevsky	

ADDITIONAL PAPERS

TS16: NDT by Heat, Optics & Othr Methods

Crack Tip Heat Emission in Fatigue Testing	716
A. Pasta	

TS23: Stress Strain Analysis – Grid and Other Methods

Computer Aided Holographic Investigation of the Deformation of Cylindrical Shells	724
P. Conti, V. Nigrelli and G. Petrucci	

TABLE OF CONTENT

Plenary Lecture I

Recent Advances in Nondestructive Evaluation in Japan	1
K. Kawashima	

TS1: Acoustic Emission

Improvement of Acoustic Emission Signal during Welding Process by Deconvolution Technique	8
S.W. Cheng and M.K. Chao	
Rapid Estimation of Endurance of Vanes Using Acoustic Emission	14
V.A. Boguslaev, S.A. Bezhenov, F.P. Banas, A.I. Bezhenov and A.B. Roitman	
Use of the Acoustic Emission for Investigating Fatigue Fracture Kinetics of Ni-Alloy	21
A.B. Roitman and S.A. Bezhenov	

TS2: Ultrasonics – Analysis of Beam

Evaluation of Ultrasonic Wave Directivity by Visualization Method	29
Y.H. Nam, K. Date and H. Takahashi	
Measurement of 3-Dimensional Sound Pressure Field in Longitudinal Wave by Photoelastic Computed Tomography	37
K. Date, T. Notaki and H. Shimada	

TS3: General I

Scheme of Computerization on Examination of NDT Personnel Qualification	44
P.K. Chen and P.H. Tong	
Status and Prospects of Nondestructive Testing and Evaluation in the Republic of Korea	49
H. Lee and O.Y. Kwon	
Applications, Costs and Benefits of Non-Destructive Testing Technology	58
M.S. Ullah	

TS4: General II

Present Status of NDT Training Courses in South East Asian Countries	66
R. Gilmour and N. Ooka	
NDT Activities in IAEA/UNDP/RCA Project	73
M. Aramrattana and N. Ooka	
Manufacture of the Specimen with Weld Defects for NDT "Application to the IAEA/UNDP/RCA NDT Training Course"	78
H. Matsumura, H. Sato, T. Ogata, H. Hirasawa and N. Ooka	

TS9: Ultrasonics – Image Processing

Imaging Technique for Ultrasonic Evaluation of Spot Welds	86
S. Satonaka, K. Yokomine and T. Takashima	
A Study of Ultrasonic Pattern Analysis of Liver Abscess	94
N. Arakawa	

TS10: Ultrasonics – Transducer and Probe

Flaw Detection and Discrimination System Using Ultrasonic Array Transducer to Inspect Weld Area of ERW Steel Pipe	100
Y. Iizuka, H. Tanabe, K. Nishifuji and A. Sato	
Coupling Layer's Transfer and Scattering Function between the Probe and the Specimen	106
K. Ohta and T. Watanabe	

TS11: Ultrasonics – Advanced Materials

Acoustoelastic Effect of Rayleigh Surface Wave in Ceramic	113
Y. Arai and E. Tsuchida	
Determination of Fiber Orientation and Lay-up Order of CFRP	121
J.O. Lee, J.S. Lee, K.S. Cho and S.Y. Lee	

Nondestructive Characterization of Metal–Matrix–Composite by Means of Ultrasonics	127
J.H. Lee and Y.C. Park	
The Reference Test Piece for Measuring Sound Velocity in Concrete by Ultrasonic Pulse Transmission Technique	136
T. Fuji, H. Nishiumi and H. Matsuyama	
TS12: Ultrasonics – Practical Application	
The Monitoring Techniques for the Fatigue Damages before the Crack Initiation of Structural Materials	142
M. Nomakuchi, T. Yoshii, K. Katsumata and H. Goto	
Development of EMAT Monitoring System of Formability in Cold–Rolled Steel Sheet	150
K. Fujisawa, R. Murayama, H. Minami, F. Yamamoto, F. Saita, H. Fukuoka and M. Hirao	
Numerical Filtering Technique for UT of Coarse–Grain Stainless Steel	158
J.F. Liu	
TS13: Eddy Current	
Automatic Inspections of Condenser Tubing by Eddy Current Testing	164
J.J. Lin, C.H. Chen, W.M. Lo and J.J. Syau	
Instantaneous Electromagnetic Energy Flow in Remote–Field Eddy Current Testing	172
H. Hoshikawa and K. Koyama	
The Deep Penetration Eddy Current Inspection for Corrosive Defects in Pipes Covered with Isolating Layer	180
F.Z. Yao, Y.B. Zhang, Q.S. An and W.H. Liu	
Influence of Speed Effect in Eddy Current Testing	185
K. Koyama and H. Hoshikawa	

TS15: Eddy Current & Magnetic Methods

An Eddy-Current Decay Transducer with Build-in Auxiliary Capacitance Element and Their Usage 193
Ya.I. Bulbik, V.V. Bulavkin, N.V. Vasilenko, A.G. Kozlov and V.G. Sheludko

On-Line NDT Measurements of Tensile Strength or Hardness of Rolled Carbon Steel Products as Heavy Plates; Warm or Cold Rolled and Zinc-Coated Strips by Use of a Magneto Inductive Testing System 199
E.L. Moser, H. Haider and B. Lutz

Eddy Current Testing for Covering Thickness and Diameter of Reinforcement in Concrete 207
J. Koido, T. Okubo and H. Hoshikawa

An Approximate Analytic-Expression for the Magnetic Leakage Field in the Region just above the Surface-Breaking Slot 214
Y.B. Zhang, K. Sekine and F.Z. Yao

Non-Destructive Evaluation of Fatigue Processes in Steels by Barkhausen Noise Method 222
Y. Furuya, Y. Ito and H. Shimada

TS16: NDT by Heat, Optics & Other Methods

Careful Determination of Inservice Inspection Location of Piping by Computer Analysis in Nuclear Power Plant 230
S.L. Lee, J.P. Lee, B.C. Kim and H.T. Lim

Development of Poolside Inspection Techniques at INER 237
L.F. Lin, Y.T. Sung, C.H. Ho, Y.H. Shiu and C.W. Yang

Optical Surface Roughness Measurement Using Two-Dimensional Gaussian Function 244
M. Kurita and H. Yamashita

Improvement of Tribology Characteristics in High Temperature Used Adjustment Method of Induced Voltages 251
Y. Yamamoto, K. Iwai and S. Takahashi

TS17: Radiography I

X-Ray Real-Time Inspection of Cold Rolled Steel Strip Inclusions	259
P.H. Tong and P.K. Lee	
Automatic Identification of the Defect Level of the Welding Seam Based on X-Ray Image	267
D.Q. Liang, W.Z. Zhen, G.H. Zhang, L.Q. Qi, Y.H. Tong and J. Hu	
A New Image Processing Algorithm for Detecting Small Defects	275
A. Ishii, V. Lachkhia and Y. Ochi	

TS25: Ultrasonics – Frequency Analysis

Dependence of Magnetoacoustic Interaction on Stress and Frequency	283
T. Yamasaki and H. Fukuoka	
A Measurement of Ultrasonic Attenuation Coefficient by Frequency Response in Steels with Different Grain Sizes	291
H. Fukuhara, C. Masuda and S. Nishijima	
Estimation of Shape Factor of Cast Iron Using Frequency Analysis of Ultrasonic Wave	299
M. Katoh, K. Nishio, T. Tsuruta, S. Mukae and Y. Ando	

TS26: Ultrasonics – New Techniques

Ultrasonic Characterization of Shape Memory Effect of NiTi Alloys	307
H. Kato, T. Ohuchi, T. Tomizawa and K. Yoshikawa	
Application of Artificial Neural Network to Defect Recognition in Acoustic Emission Testing during Welding Process	313
S.W. Cheng and M.K. Chao	
Measurement of Temperature-Dependence of Acoustoelastic Birefringence with Digital Zero-Crossing Method	319
I. Fujii, K. Kawashima, T. Ito and Y. Sugiyama	
Application of Artificial Neural Network in Intelligent Ultrasonic Flaw Detector	325
J.F. Tan, W.X. Tan and X.D. Dong	

TS27: Radiography II

General Analysis to Errors in Stereoscopic Radiographic Observing and Measuring 331
Y.J. Du, F.H. Liu and Z.L. Yang

Research on the Three-Dimensional Localization for Interior Defects within
Circumferential Welded Seams of Pressure Vessels 338
F.H. Liu, Y.J. Du, B. Wang and X.J. Liu

TS28: Radiography III

Microfocus Radioscopy of Light Metal Casting Processes 344
D. Stegemann, W. Reimche and K. Feiste

Nondestructive Density Measurements on Green P/M Sheets Using
Gamma-Ray Source 353
K.S. Cho, J.O. Lee, S.Y. Lee and J.S. Lee

Combined Method of High Resolution X-Ray Computed Tomography and
Acoustic Emission for Nondestructive Testing 361
K. Hayashi, H. Yamaji, Y. Nagata and T. Ishida

A Survey of Recent Stress-Strain Measurement in Japan

Susumu TAKAHASHI

Faculty of Engineering, Kanto Gakuin University, 4834 Mitsuura
Kanazawa-ku, Yokohama 236, JAPAN

1. Introduction

With recent remarkable technical development, requirements for safety have been increasingly augmented, and with improvement of functions of various machines, conditions for using those machines have become more and more strict and exacting. In this connection, more and more rigorous technique of experimental stress analysis is being required, yet at the same time the area of its application is getting expanded to the extent of including other disciplines such as medicine.

Under these circumstances, techniques of experimental stress analysis are making progress with the years in Japan as elsewhere. A bird's-eye view of the whole picture would be something like this: researches related to computers are on the increase, together with studies on new measuring methods based on new principles. Included among them are such studies as attempt to enable formerly difficult measurement to enlarge its scope of application by partial improvement of the existing method, and studies that intend to enlarge former laboratory measuring method to field measurement by labor-saving of data processing. As for the objects of research, such as are connected in some form with fracture mechanics(which is in much demand today) are becoming dominant. In regard to the methods of measurement, analytical methods making use of Caustics and Grid Method and X-rays are increasing together with analytical methods based on optical principles and strain gage methods, and those methods which are related to measurement of residual stress are also predominating.

The present situation of experimental stress analysis techniques in Japan will be described below. It is to be noted, however, that there are many excellent studies that are not mentioned here due to limited space. As for activities of learned societies on stress and strain analysis, numerous papers are read every year in the meetings of the Japan Society of Mechanical Engineers, Japanese Society for Nondestructive Inspection(JSNDI), Japan Society for Photoelasticity and so on, and the Symposium on Stress and Strain Measurement is held once a year.