TITANIUM 1986

Products and Applications

Proceedings of the Technical Program

from the

1986 International Conference

VOLUME II

Published by

TITANIUM DEVELOPMENT ASSOCIATION
INDUSTRIAL APPLICATIONS (continued)

Titanium Elastic Properties and Applications.............................................523
  S. R. Seagle, RMI Company
  C. P. Pepka, Renton Coil Spring Company
  R. Majoraitis, Boeing Commercial Airplane Company

Titanium Resista-Clad (TM) Plate in Flue Gas Desulfurization Units.............532
  Mark X. Cerny, The Pfaudler Company

The Use of Ti-6Al-4V Alloy in the "Nautille" Deep Submergence Vessel..........538
  Y. Millet, CEZUS Company
  A. Dergalenko, CEZUS Company
  Mrs. Gaillard, Société Technique des Constructions Aéronavales
  E. Alheritiere, CEZUS Company

Spherical Pressure Hull Made from Titanium Alloy for Deep Submergence Research Vehicle..................................................564
  Takashi Nishimura, Kobe Steel, Ltd.
  Masahito Fukuda, Kobe Steel, Ltd.
  Yoshimasa Itoh, Kobe Steel, Ltd.
  Ken-ichi Yasui, Kobe Steel Ltd.
  Hiroshi Yuguchi, Kobe Steel Ltd.
  Yoshihiro Fukuhara, Kobe Steel, Ltd.

Compact High Performance Exchanger (ACX)...........................................571
  J. E. Deily, Astro Division of Harsco Division

POSTER SESSIONS:
Anodizing Titanium.................................................................584
  J.-L. Delplancke, Université Libre de Bruxelles
  R. Winand, Université Libre de Bruxelles

Fatigue Behavior of TiNi Shape Memory Alloy.....................................593
  Hisaoaki Sasano, National Research Institute for Metals
  Toshiyuki Suzuki, National Research Institute for Metals

JOINING

Titanium Diffusion Bonding in the Manufacture of Aircraft Structure...........603
  D. Stephen, British Aerospace plc

Laser Nitriding and Carburizing of Ti-6Al-4V Titanium Alloy....................631
  G. Coquerelle, ETCA Tribology and Treatments Lab.
  J. P. Massoud, ETCA Tribology and Treatments Lab.
  M. Collin, ETCA Tribology and Treatments Lab.

Inertia Friction Welding of Titanium..................................................640
  Al S. Wadleigh, Interface Welding
JOINING (continued)

Electron Beam Welded Titanium Alloys in Rolls-Royce Aero Engines.......... 653
R. H. Broomfield, Rolls-Royce plc

Fracture Toughness of Two Titanium Alloys Welded by High Energy Density Process.......................................................... 663
T. S. Baker, Royal Aircraft Establishment
M. F. Gittos, The Welding Institute
J. R. Gordon, The Welding Institute
M. H. Scott, The Welding Institute

Thermal Cutting of Titanium: The Forgotten Process.......................... 680
Richard Woolman, Plasma Cutting Service

The Rolls-Royce Wide Chord Fan Blade............................................ 685
G. A. Fitzpatrick, Rolls-Royce plc
T. Broughton, Rolls-Royce plc

Diffusion Joint Between Titanium and Aluminum Oxide by AES............. 703
J. K. Sirviö, Helsinki University of Technology

MEDICAL APPLICATIONS

Developments of a Titanium Based Alloy for Medical Implants................ 712
M. Sen, Burn Standard Co. Ltd.

Classic and New Titanium Alloys for Production of Artificial Hip Joints.... 721
M. Semlitsch, Sulzer Brothers Ltd.

Overall Improvement of Titanium-Based Orthopaedic Implants by
Ion Implantation (Ionguard/TM)..................................................... 741
Piran Sioshansi, Spire Corporation

Properties of Ti-22V-4Al Beta Titanium Alloy for Eyeglass Frames........... 748
Yuzo Ohtakara, Daido Steel Co., Ltd.
Motoaki Imamura, Daido Steel Co., Ltd.
Ako Hiro Suzuki, Daido Steel Co., Ltd.
Sho ichi Fukui, Daido Steel Co., Ltd.

POWDER METALLURGY

Titanium Powder Metallurgy--Products and Applications........................ 758
F. H. Froes, U.S. Air Force Materials Laboratory
D. Eylon, University of Dayton
R. G. Rowe, General Electric Company

viii
POWDER METALLURGY (continued)

Powder Metallurgy (P/M) Near Net Shape Titanium Components
from Prealloyed Powder
C. F. Yolton, Crucible Materials Corporation
J. H. Moll, Crucible Materials Corporation

Current and Future Opportunities for Near-Net Titanium P/M Parts
R. H. Hitt, Grumman Aircraft Systems

Significant Cost Savings for the Manufacture of Near-Net Shape
Titanium Alloy Components by Advanced Powder Metal Technology
Stanley Abkowitz, Dynamet Technology Inc.
David M. Rowell, Dynamet Technology Inc.

Blended Elemental Powder Titanium for Automotive Applications
E. S. Brosius, Clevite Industries Inc.
J. C. Malek, Clevite Industries Inc.
N. K. Petek, Clevite Industries Inc.
M. J. Trzcinski, Clevite Industries Inc.

POSTER SESSIONS:
Effect of Oxygen on the Martensitic Transformation Temperature of
the TiNi Compacts Prepared by Blended Elemental Powder Metallurgy
Shigeaki Uehara, National Research Institute for Metals
Hisaoki Sasano, National Research Institute for Metals
Toshiyuki Suzuki, National Research Institute for Metals

Improvement of Mechanical Properties of Blended Elemental α-β Ti
Alloys by Microstructural Modification
Masuo Hagiwara, National Research Institute for Metals
Yoshinari Kaieda, National Research Institute for Metals
Yoshikuni Kawabe, National Research Institute for Metals

RAW MATERIALS, MELTING, CASTING and RECYCLING

Product Characteristics of a Start-Up Kroll Reduction Plant
S. DeLeón, International Titanium of Washington, Inc.

Machine Turnings -- A Proven Source of Recyclable Titanium Scrap
J. P. Laughlin, OREMET Titanium

Developments of Melting and Casting Technology of Titanium Base Alloys
M. Sen, Burn Standard Company, Ltd.

Hearth Melting of Reactive and Refractory Metals Using Plasma Arcs
M. P. Schlienger, Retech, Inc.
R. C. Eschenbach, Retech, Inc.
Electron Beam Melted "In-Spec" Titanium Remelt Electrodes.......................... 904
H. E. Herman, Viking Metallurgical Corp.
V. K. Forsberg, Viking Metallurgical Corp.

Plasma Consolidation of Large Diameter Titanium Electrodes...................... 918
S. Stocks, OREMET Titanium
D. Hiatt, OREMET Titanium

Package Melting of Titanium Alloys Scraps and Its Products...................... 928
Y. Mae, Mitsubishi Metal Corp.
T. Oka, Mitsubishi Metal Corp.
S. Yamazaki, Mitsubishi Metal Corp.

Electron Beam Hearth Refining of Titanium........................................ 939
Howard R. Harker, A. Johnson Metals Corporation
Charles H. Entrekin, A Johnson Metals Corporation

High Purity Titanium for New Uses.............................................. 948
J. Iseki, Osaka Titanium Co., Ltd.
A. Moriya, Osaka Titanium Co., Ltd.
T. Hashioka, Osaka Titanium Co., Ltd.
M. Katsumaru, Osaka, Titanium Co., Ltd.

POSTER SESSIONS:
Effect of Sample Preparation on the Results of the Analytical
Evaluation of Raw Materials for Titanium........................................ 952
Charles K. Deak, Analytical Associates, Inc.

Review of Titanium Alloy Turnings Recycling.................................... 959
J. E. Dresty, Jr., Suisman Titanium Corporation

Raw Material, Melting, Casting, Recycling: Critical Review.................... 963
K.-H. Kramer, Schmiedewerke Krupp-Klockner GmbH

Development of the Plasma Progressive Casting Process
and Its Application for Titanium Melting........................................ 985
T. Yajima, Daido Steel Company
O. Tamari, Daido Steel Company
H. Kamiya, Daido Steel Company
S. Hiratake, Daido Steel Company
Y. Kakanishi, Daido Steel Company
K. Kato, Daido Steel Company
H. Yamada, Daido Steel Company
K. Yoshida, Daido Steel Company

Raw Materials for the Production of Titanium.................................... 994
RAH MATERIAL, MELTING, CASTING, RECYCLING (continued)

Solidification and Segregation in Titanium Alloys...........................1011
A. Mitchell, The University of British Columbia
D. Tripp, The University of British Columbia

Factors Which Effect the Quality of Titanium Casting......................1020
J. D. Dippel, TiTech International, Inc.

SUPERPLASTIC FORMING

Superplastic Forming of Titanium--A Production Viewpoint..................1034
P. N. Comley, Murdock, Inc.

Application of Superplastic Forming for the Satellite Tank Fabrication.....1060
P. J. Winkler, Messerschmitt-Bolkow-Blohm GmbH
H. Pertler, Messerschmitt-Bolkow-Blohm GmbH

Effect of Recrystallization on the Superplastic Behavior of Ti-6Al-4V........1073
J. L. Brantingham, RMI Company
D. E. Thomas, RMI Company

Superplastic Forming/Diffusion Bonding of Titanium:
An Air Force Overview.................................................1087
John R. Williamson, Air Force Wright Aeronautical Labs

Production Implementation of Titanium Superplastically Formed/
Diffusion Bonded Structure...........................................1107
Walter Leodolter, McDonnell Douglas Corporation

R Values of Titanium Alloys After Superplastic Strain......................1113
C. D. Ingelbrecht, Royal Aircraft Establishment

SPF/Titanium and the B-1B Aircraft...................................1126
G. W. Stacher, Rockwell International

Quality Assurance--The Key to Advanced Aircraft Engine Applications
of the SPF/DB Process..................................................1136
A. F. Evans, General Electric Aircraft Engine Group
J. L. Bartos, General Electric Aircraft Engine Group

SPF/DB Applications for Military Aircraft................................1153
Bruno Rolland, Avions Marcel Dassault, Breguet Aviation

POSTER SESSIONS:
Superplastic Behaviour of Ti-6Al-4V Alloy Investigated by
Torsion Testing......................................................1163
Y. Combres, Ecole des Mines de PARIS
C. Levaillant, Ecole des Mines de PARIS
F. Montheillet, Ecole des Mines de PARIS

xi
SUPERPLASTIC FORMING (continued)

Numerical Modeling of 3-Dimensional Superplastic Forming of Titanium Sheet

M. Bellet, Ecole des Mines de PARIS
J. L. Chenot, Ecole des Mines de PARIS