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19. ABSTRACT (Continue on reverse if necessary and identify by block number) It was apparent from the papers presented that the research and development activity in the area of superplasticity and superplastic forming is of substantial interest world-wide, and a number of papers reported results that are considered to be significant and which may point the direction for future research that should prove fruitful. Noteworthy among these are 1) the activities addressing high rate superplasticity, through both alloy development and process concept studies, 2) computer modeling of the SPF process, including finite element methods coupled with 3-D color graphics displays of thinning characteristics, 3) superplasticity in ceramic and inter-metallic compound materials, 4) solid-state joining (diffusion bonding) of aluminum alloys, 5) demonstration that there are microstructural concepts other than that of fully recrystallized structure which can lead to superplasticity, especially at high rates, and 6) significant extension in the state of understanding of the interrelationship between microstructural dynamics and superplastic properties, including fundamentals of superplasticity and cavitation.			
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AFOSR-TK- 88-1079

FINAL REPORT

INTERNATIONAL CONFERENCE ON SUPERPLASTICITY
AND SUPERPLASTIC FORMING

August 1-4, 1988

Blaine, Washington

Report To

Air Force Office of Scientific Research
(Contract No. AFOSR88 0158)

C. H. Hamilton
Washington State University
Pullman, WA

N. E. Paton
Rockwell International
Canoga Park, CA

August 9, 1988



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The International Conference on Superplasticity and Superplastic Forming was held at the Inn at Semiahmoo in Blaine, WA on 1-4 August, 1988. There were 144 attendees registered, and approximately 107 papers were presented, including 67 oral presentations and 40 posters. Attendees represented 17 different countries. Enclosed are copies of the program and list of attendees. The proceedings will be published by The Metallurgical Society, and should be available about November, 1988. Copies will be forwarded to AFWAL when they are available.

It was apparent from the papers presented that the research and development activity in the area of superplasticity and superplastic forming is of substantial interest world-wide, and a number of papers reported results that are considered to be significant and which may point the direction for future research that should prove fruitful. Noteworthy among these are 1.) the activities addressing high rate superplasticity, through both alloy development and process concept studies, 2.) computer modeling of the SPF process, including finite element methods coupled with 3-D color graphics displays of thinning characteristics, 3.) superplasticity in ceramic and intermetallic compound materials, 4.) solid-state joining (diffusion bonding) of aluminum alloys, 5.) demonstration that there are microstructural concepts other than that of fully recrystallized structure which can lead to superplasticity, especially at high rates, and 6.) significant extension in the state of understanding of the interrelationship between microstructural dynamics and superplastic properties, including fundamentals of superplasticity and cavitation development.

It is now clear that the concepts of superplastic forming as being a slow forming process (ie., requiring times of the order of 15 minutes to several hours) are no longer valid. Superplasticity at strain rates in the range of .1 to 2.5 s⁻¹ have been reported. For example, the work of Beiler et al (paper 60), Matsuki et al (paper 84), and Ghandi et al (paper 14) clearly show that very high rate superplasticity is possible, especially if dynamic recrystallization processes are involved during the superplastic deformation. In addition, concepts of variable strain rate deformation processing, rather than constant strain rate, also hold promise for increasing the SPF process rate as

indicated by Ohsawa (paper 61), Ash et al (paper 42), and Ghosh (paper 68).

Perhaps the most exciting new developments in superplasticity are those in the area of "difficult-to-form" materials, such as the ceramics, intermetallic compounds, composites and mechanically alloyed metals. For example, it was reported that a ceramic material (Y-TZP ZrO_2) was just recently stretched in tension to an elongation of over 900%, and exceptional achievement (paper 9). Superplastic forming appears to offer an effective way of shaping many other materials, such as Ti aluminides and other intermetallic compounds, as well as certain metal matrix composites.

The applications of SPF parts continues to increase both in aerospace and non-aerospace areas. Titanium continues to be the primary material processed for aerospace, although the development in Al SPF is accelerating and utilization is increasing as new commercial alloys become available. A number of Ti, Al, Fe, and Ni alloy parts were shown by the European, Chinese, and Russian authors (eg. papers 1,22, 26, 27, 52, 76, 77, 78, 97, 106, and 107).

It is noteworthy that in several countries, there are nationally coordinated research groups on superplasticity. Such groups include the Japan Research Group on Superplasticity, a similar group in the Peoples Republic of China, a Center for the Study of Superplasticity Problems in the USSR with 500 researchers, and group recently established in the United Kingdom for exchange of ideas and information on superplasticity.

The Organizers decided to establish a "Best Paper" award for the manuscripts submitted for the Conference, and present the author(s) with a \$500 honorarium. The award was based on the written manuscripts only. The award was presented to T. R. Bieler, T. G. Nieh, J. Wadsworth, and A. K. Mukherjee for their paper "*High Rate Superplastic Behavior of Mechanically Alloyed Al IN90211*" (paper 60) based on the significance, technical quality and clarity of their paper.

The Organizing Committee met during the Conference to discuss the interest and research progress in superplasticity, and to explore the need for future conferences. It was the conclusion of the Committee that interest in superplasticity and related progress were sufficient to justify a subsequent international conference, and it was agreed

that Japan would host the next conference, and that it would be scheduled for 1991. The specific site and date will be identified at a later date by the Japanese members of the Organizing Committee.

The following Appendices include the list of attendees and a copy of the program for the Conference.

APPENDIX A

PROGRAM

**International Conference on Superplasticity
and Superplastic Forming**

INTERNATIONAL CONFERENCE ON SUPERPLASTICITY AND SUPERPLASTIC FORMING

TECHNICAL PROGRAM

SUNDAY, JULY 31

15:30 - 19:00 Registration in Ballroom Lobby

17:00 - 19:00 Social Mixer featuring a San Francisco pasta bar, beer and wine in Blakely Room

MONDAY, AUGUST 1

7:00 - Registration and coffee/pastries in Ballroom Hallway

8:00 - Welcoming Comments - C. Howard Hamilton, Conference Co-Chair

All meetings will be held in the Cypress and Orcas Rooms.

MONDAY, AUGUST 1

SESSION I: FUNDAMENTALS

Chair: C. Howard Hamilton, Washington State University, U.S.A.

Keynote Speaker

- 8:15 Paper 1 O. A. KAIBYSHEV, USSR Academy of Sciences
Current Problems of the Material Science of Superplasticity
- 8:50 Paper 2 SHIGENORI HORI and NORIO FURUSHIRO, Osaka University
Metallographical Research on Superplasticity
- 9:10 Paper 3 M. J. MAYO, Sandia National Laboratories and W. D. NIX, Stanford University
Direct Observations and Micromechanical Testing of Superplastic Alloys
- 9:30 Paper 4 G. S. MURTY, Indian Institute of Technology and M. J. KOCZAK, Drexel University
Investigation of Region I in Rapidly Solidified Powder Al Alloys
- 9:50 Break
- 10:10 Paper 5 R. I. TODD and P. M. HAZZLEDINE, Oxford University
The Mechanism of Superanelasticity and its Implications
- 10:30 Paper 6 SHANYOU ZHOU, LIQIN WANG and CHIN LIU, Shanghai Jiao Tong University
The Role of Grain Boundary Dislocations During Superplastic Deformation of an Al Alloy
- 10:50 Paper 7 R. Z. VALIEV, USSR Academy of Sciences
The Physical Model of Superplasticity Based on the Notion of Non-equilibrium Grain Boundaries
- 11:10 Paper 8 G. TORRES VILLASEÑOR, Universidad Nacional Autónoma de México and J. NEGRETE, Universidad Autónoma de San Luis Potosí
Superplastic Behavior of Zn-20Al-2Cu at Room Temperature and Deformation Mechanisms

11:30 Paper 9 J. WADSWORTH, T. G. NIEH, Lockheed Missiles & Space Company, Inc.,
and OLEG SHERBY, Stanford University
*Some Recent Advances in the Development of Fine-grained Superplastic Al
Alloys, Ceramics, and Laminated Composites*

12:15 Lunch in Blakely Room

MONDAY, AUGUST 1

SESSION II: MICROSTRUCTURAL DYNAMICS

Chair: Peter Partridge, Royal Aircraft Establishment, England

Keynote Speaker

13:50 Paper 10 D. S. WILKINSON, McMaster University
Microstructural Instability During Superplastic Flow

Keynote Speaker

14:25 Paper 11 R. GRIMES, Alcan International Limited
Microstructural Evolution in Superplastic Al Alloys

15:00 Paper 12 N. G. ZARIPOV and R. O. KAIBYSHEV, USSR Academy of Sciences
Dynamic Recrystallization and Superplasticity of a Mg Alloy

15:20 Break

15:40 Paper 13 JIN QUANLIN, BAI BINGZHE, LAI WEIHUA, GUO XUSHENG and
ZHANG HONG, Beijing Research Institute of Mechanical and Electrical
Technology of SIME
Grain Refinement by Torsion and Superplasticity in High-strength Al Alloy

16:00 Paper 14 CHIMATA GANDHI and AMIT K. GHOSH, Rockwell International Science
Center
Superplasticity in High-strength Al Alloys

16:20 Paper 15 G. A. SALISHCHEV and R. Ya. LUTFULLIN, USSR Academy of Sciences
The Transformation of Ti Alloy Laminar Microstructure into a Microduplex One

16:40 Paper 16 P. LUKÁČ, Charles University
The Role of Matrix Dislocations in the Superplastic Deformation

17:00 Paper 17 EIICHI SATO, KAZUHIKO KURIBAYASHI AND RYO HORIUCHI, The
Institute of Space and Astronautical Science
*Superplastic Deformation Induced Grain Growth in Microduplex and Second
Phase Dispersed Alloys*

Dinner on your own.

SESSION III: POSTER SESSION
20:30 - 22:30 in the Ballroom Lobby

Paper 18 D. V. DUNFORD and P. G. PARTRIDGE, Royal Aircraft Establishment
Deformation of Ti-6Al-4V Bar and Extrusion Under Superplastic Forming Conditions

Paper 19 N. DYULGEROV, A. ISTATKOV, N. MITEV, and I. SPIROV, Bulgarian Academy
of Sciences
Superplastic Low Manganese Zinc-Manganese Alloys

- Paper 20 P. GRUFFEL, P. CARRY and A. MOCELLIN, École Polytechnique Fédérale de Lausanne
Effect of Testing Mode on Superplastic Creep of Fine Grained Alumina
- Paper 21 K. OSADA, Nippon Yakin Kogyo Co., Ltd.
Properties of a Microduplex Stainless Steel Superplastically Deformed
- Paper 22 R. FURLAN, P.-J. WINKLER, MBB Central Laboratories, D. HAGG and L. REISINGER, MTU Development Manufacturing
Production of Ti-6Al-4V-Components for a New Turbo-Fan-Engine
- Paper 23 R. A. RICKS, J. BALL, Alcan International Limited; H. STOKLOSSA, MBB Central Laboratories, P.-J. WINKLER, MBB Central Laboratories, and R. GRIMES, British Alcan Aluminium
Bonding of Al-Li Base Alloys Using Roll Clad Zn Interlayers
- Paper 24 WANG YANWEN, FENG ZEZHOU and SUN SHANGCHEN, Beijing Research Institute of Mechanical and Electrical Technology of SCMI
Transformation Superplasticity Solid-state Bonding in Steels
- Paper 25 P. G. PARTRIDGE and D. V. DUNFORD, Royal Aircraft Establishment
Effect of Superplastic Deformation on the Surface Roughness of Sheet
- Paper 26 LI YOU-QIN and ZHANG SHI-LING, Beijing Aeronautical Manufacturing Technology Research Institute
Study on SPF and SPF/DB of the Bulkhead Structure with Nonsymmetric Shape
- Paper 27 HAI JINTAO, LU XIN, YANG LUYI, ZHANG GUOPIN and BAI BINZHE, Beijing Research Institute of Mechanical and Electrical Technology of SCMI
Superplastic Forming of Ti-Alloy Turbine Blade
- Paper 28 WANG CHENG and LUO YING-SHE, Xiangtan University
New Advance of Superplastic Forming Process for Commercial Structural Alloys
- Paper 29 SONG YU-QUAN, Jilin University of Technology; ZHANG ZHEN-JUN, Chinese Academy of Agricultural Mechanization Sciences and LIAN SHU-JUN, Jilin University of Technology
Mechanical Analysis About Deformation Laws of Superplastic Extrusion Through Cone-shaped Dies
- Paper 30 MURRAY W. MAHONEY and ROY CROOKS, Rockwell International Science Center
Mechanisms of Superplastic Flow in Inconel 718
- Paper 31 HUANG LIPING, Shanghai Iron & Steel Research Institute
The Study of Reducing Superplastic Temperature in Ti Alloys
- Paper 32 SU SHENGGUI, SHEN HUANXIANG and SONG SHENG-ZHE, Northeast Institute of Heavy Machinery
An Approach to the Superplasticity of Al Brass (HAL 66-6-3-2)
- Paper 33 J. J. BLANDIN, Institut National Polytechnique de Grenoble; J. Y. LACROIX, Centre de Recherches et Développement Cégédur-Pechiney and M. SUÉRY, Institut National Polytechnique de Grenoble
Superplasticity and Cavitation of the 2091 Al-Cu-Li-Mg Alloy

- Paper 34 WANG CHUNRONG, SONG HAILONG, QU LI and CHAO SHUZHI, Institute of⁴
Metal Research, Academia Sinica
*Superplastic Formability to Distinguish the Metallic Thin Wall Components by Criteria
and Criterion-model*
- Paper 35 TONY BARNES, R. BUTLER, M. J. REYNOLDS, Superform Metals, R. GRIMES,
and W. S. MILLER, Alcan International Ltd.
*Forming Characteristics of Structural Al Alloys (Combined with "Forming
Characteristics and Mechanical Properties of Superplastic Al-Li Based Alloys 8090 and
8091")*
- Paper 36 ATUL H. CHOKSHI and AMIYA K. MUKHERJEE, University of California-
Davis
*The Influence of Hydrostatic Pressure on Cavitation and Failure in Superplastic Al-
based Alloys*
- Paper 37 A. VARLOTEAUX, J. J. BLANDIN and M. SUÉRY, Institut National
Polytechnique de Grenoble
Influence of Uni- and Bi-axial Straining on Cavitation in a Superplastic Al Alloy
- Paper 38 K. HIGASHI, University of Osaka Prefecture and N. RIDLEY, University of
Manchester/UMIST
Thermomechanical Processing and Superplasticity in a Commercial Cu-base Alloy
- Paper 39 PARVIN SHARIAT, Northrup University and TERENCE G. LANGDON,
University of Southern California
*The Influence of Specimen Profile and Notch Geometry on Superplasticity in Zn-22%
Al*
- Paper 40 CHEN HECHUN and YANG ZHENHENG, Northwestern Polytechnical University
The Relationship Between Strain-rate Sensitivity Index and Strain in Superplasticity
- Paper 41 C. HAMMOND, A. NICHELLS, University of Leeds, and N. E. PATON, Rockwell
International
*Photoemission Electron Microscopy of Superplastic Deformation Mechanisms in Al
Alloy 7475 and Ti Alloy Ti-6%Al-4%V*
- Paper 42 B. ASH and C. H. HAMILTON, Washington State University
Factors Affecting Superplastic Stability in an Al-Li-Cu-Zr Alloy
- Paper 43 BINYAN REN and C. H. HAMILTON, Washington State University
*The Microstructural Characteristics of an Al-Li-Cu-Mg-Zr Alloy During the Initial
Stage of Superplastic Deformation*
- Paper 44 JIANZHONG CUI, QINLING WU and LONGXIANG MA, Northeast University of
Technology
Effect of Grain Size on Region Transition Behavior in Superplastic Deformation
- Paper 45 R. D. TUCKER and C. H. HAMILTON, Washington State University
*The Effects of Superplastic Deformation on the Microstructure and Hardening
Characteristics of High Strength 8091 Al-Li Alloy*
- Paper 46 L. R. ZHAO, S. Q. ZHANG and M. G. YAN, Institute of Aeronautical Materials
*Details of the Alpha Grain Boundaries in Annealed and Superplastically Deformed Ti-
6Al-4V Alloy*
- Paper 47 L. R. ZHAO, S. Q. ZHANG and M. G. YAN, Institute of Aeronautical Materials
Improvement in the Superplasticity of Ti-6Al-4V Alloy by Hydrogenation

- Paper 48 Z. R. WANG, XU YANWU, GUO DIANJIANG, Harbin Institute of Technology, YIN CHANGKUI, Beijing Agricultural Engineering University
An Experimental Study of Yield Criteria Using Superplastic Thin-walled Tubes Subjected Tension-torsional Combined Loads
- Paper 49 HAILING HUANG, Changchun Institute of Optics & Fine Mechanics Academia Sinica, QINGLING WU, Northeast University of Technology, and JIN HUA, Changchun Institute of Optics & Fine Mechanics Academia Sinica
A Study on Superplasticity of Commercial 2024Al Alloy
- Paper 50 PAN YA QIN, LIU WEIMIN and SONG ZUOZHOU, Beijing Institute of Aeronautics and Astronautics
Superplasticity in Ti-10V-2Fe-3Al Alloy
- Paper 51 XI JUKUI, XU CHUNHUA, and YANG YUNLIN, Luoyang Institute of Technology
Superplastic Boriding of Steel
- Paper 52 J. WITTENAUER, P. SCHEPP and B. WALSER, Sulzer Brothers AG
Application of Superplastic UHC Steel for Isothermal Forging of Machine Component
- Paper 53 ZHAO MIN and CHEN PUQUAN, Harbin Institute of Technology
A Complex Deformation Mechanism for Superplastic Deformation of Mg Alloys
- Paper 54 JIN TAO, ZHAO MIN and CHEN PUQUAN, Harbin Institute of Technology
A Deformation Mechanism for Superplastic Deformation of Age Strengthening Cu Alloy
- Paper 55 HAN SHUZHI, Northeast University of Technology
Study on Improving the Performance of Zn-22%Al Eutectoid Superplastic Alloys
- Paper 56 J. F. YANG, PENG XU AND H. WANG, Harbin Institute of Technology
Effects of Second Phase Particles on the Cavity of Superplasticity
- Paper 57 TAKAYUKI NAGANO, HIDEZUMI KATO, Suzuki Motor Co. Ltd. and FUMIHIRO WAKAI, Government Industrial Research Institute
Diffusion Bonding of ZrO₂/Al₂O₃ Composite

TUESDAY, AUGUST 2

SESSION IV: RHEOLOGY and CAVITATION
Chair: Oleg Sherby, Stanford University, U.S.A.

Keynote Speaker

8:00 Paper 58 B. BAUDELET and M. SUÉRY, Institut National Polytechnique de Grenoble
Plastic Stability and Strain to Fracture During Superplastic Deformation

Keynote Speaker

8:35 Paper 59 ATUL H. CHOKSHI and AMIYA MUKHERJEE, University of California-Davis
The Role of Cavitation in the Failure of Superplastic Alloys

9:10 Paper 60 T. R. BIELER, University of California-Davis, T. G. NIEH, J. WADSWORTH, Lockheed Missiles and Space Co., Inc. and A. K. MUKHERJEE, University of California-Davis
High Rate Superplastic Behavior of Mechanically Alloyed Al IN90211

- 9:30 Paper 61 H. OHSAWA, Hosei University
Effect of Accelerated/Decelerated Strain Rate on Sheet Formability of $\sigma = K\dot{\epsilon}^m \epsilon^n$ Materials
- 9:50 Break
- 10:10 Paper 62 YAN MA and TERENCE G. LANGDON, University of Southern California
An Investigation of the Characteristics of Cavitation in Superplastic Materials
- 10:30 Paper 63 O. M. SMIRNOV, Moscow Steel and Alloys Institute
Rheological Criteria for Rational Use of Superplasticity in Metal Working by Pressure
- 10:50 Paper 64 TAKUJI OKABE, Kure National College of Technology, TOMEI HATAYAMA, Hiroshima University and HIDEO TAKEI, Hiroshima Institute of Technology
Effect of Strain Rate Dependence of m on Ductility in Superplastic Materials
- 11:10 Paper 65 J. J. BLANDIN and M. SUÉRY, Institut National Polytechnique de Grenoble
Evolution of Cavitation During Superplastic Deformation
- 11:30 Paper 66 NORIO FURUSHIRO, Osaka University and TERENCE G. LANGDON, University of Southern California
An Experimental Investigation of Hole Growth and Interlinkage in the Superplastic Zn-22% Al Eutectoid Alloy
- 11:50 Paper 67 ZHAO YOU-CHANG and LI XIU-QING, Jilin University
Cavitation Behavior and Dislocation Structure of Commercial Mn-Brass During Superplastic Deformation
- 12:15 Lunch in Blakely Room

TUESDAY, AUGUST 2

SESSION V: FUNDAMENTALS OF FORMING

Chair: Peter Winkler, MBB, West Germany

Keynote Speaker

- 13:00 Paper 68 A. K. GHOSH, Rockwell International Science Center
Role of Microstructure and Mechanics on Superplastic Forming

Keynote Speaker

- 13:35 Paper 69 MASARU KOBAYASHI, Technological University of Nagaoka
Novel Processing Methods for Superplastic Alloys
- 13:55 Paper 70 N. CHANDRA and B. ROY, Florida State University
Membrane Element Analysis of Axisymmetric and Non-axisymmetric Superplastic Metal Forming Processes
- 14:15 Paper 71 J. BONET, R. D. WOOD and O. C. ZIENKIEWICZ, University College of Swansea
Finite Element Modelling of the Superplastic Forming of Thin Sheet
- 14:35 Break

- 14:50 Paper 72 J. M. STORY, Aluminum Company of America
Incorporation of Sliding Friction into a Closed-form Model of Plane Strain Superplastic Forming
- 15:10 Paper 73 Z. X. GUO, University of Manchester/UMIST, J. PILLING, Michigan Technological University and N. RIDLEY, University of Manchester/UMIST
Bulge-forming of Domes: A Comparison of Theoretical Prediction and Experiment
- 15:30 Paper 74 TAO SHUXUE and MA LONGXIANG, Northeast University of Technology
A Study on Superplastic Alloy Sheet Bulging Under the Microcomputer Control
- 15:50 Paper 75 J.-L. LEBRUN, M. RESZKA and M. FOULON
Development of a Characterization Test of Materials and of the Parameters for Superplastic Forming of Al Alloys
- 16:10 Paper 76 CHEN BINGKUN and HAI JINTAO, Beijing Research Institute of Mechanical and Electrical Technology of SCMI
Superplastic Forming of Ti-Alloy Vessel
- 16:30 Paper 77 S. D. VISWANATHAN, S. VENKATASAMY and K. A. PADMANABHAN
Theoretical and Experimental Studies on the Pressure Thermo-forming of Hemispheres of Alloy Ti-6Al-4V
- 16:50 Paper 78 B. PLEGE
On the Importance of Microstructure and Forming Parameters in the Manufacture of Ti-6Al-4V SPF/DB Parts

Dinner on your own.

WEDNESDAY, AUGUST 3

SESSION VI: ALLOY DESIGN

Chair: Norman Ridley, University of Manchester/UMIST

Keynote Speaker

- 8:00 Paper 79 M. YAMAZAKI, National Research Institute for Metals, Japan
Alloy Design of Superplastic Ni-base and Ti-base Alloys

Keynote Speaker

- 8:35 Paper 80 N. RIDLEY, University of Manchester/UMIST and C. HAMMOND, University of Leeds
Development of Superplastic Behaviour in Various Commercial Materials

- 9:10 Paper 81 R. A. RICKS, Alcan International Limited and P.-J. WINKLER, MBB Central Laboratories
Superplastic Optimisation for Diffusion Bonding Applications in Al-Li Alloys

- 9:30 Paper 82 ZHOU TIECHENG, ZHANG ZHIMIN, ZHANG YANHUI, Taiyuan Institute of Machinery and TANG DEFEN, Beijing Nonferrous Metals and Rare Earth Research Institute
The Development of LFC-X1 Alloy

- 9:50 Break

- 10:10 Paper 83 R. CROOKS, Rockwell International Science Center, S. J. HALES and T. R. McNELLEY, Naval Postgraduate School
Microstructural Refinement via Continuous Recrystallization in a Superplastic Al Alloy
- 10:30 Paper 84 K. MATSUKI, M. TOKIZAWA, Toyama University and G. STANIEK, Institut für Werkstoff-Forschung
Superplasticity of Rapidly Solidified 7475-0.7 Wt% Zr Alloys
- 10:50 Paper 85 I. I. NOVIKOV and V. K. PORTNOY, Moscow Steel and Alloys Institute
Optimization of Heterogeneity as General Principle of Controlling Alloys Structure for Superplastic Forming
- 11:10 Paper 86 S. YAMAZAKI, T. OKA, Y. MAE, Mitsubishi Metal Corp., and M. KOBAYASHI, Technological University of Nagaoka
Superplastic Properties of the Cold Formable Ti Alloy SP35
- 11:30 Paper 87 I. KUBOKI, Y. MOTOHASHI and M. IMABAYASHI, Ibaraki University
Grain Refinement and Superplasticity in a Hard Ni-base Alloy
- 12:15 Lunch in Blakely Room

WEDNESDAY, AUGUST 3

SESSION VII: SPF METHODS and DIFFUSION BONDING
Chair: Amit Ghosh, Rockwell International Science Center, U.S.A.

Keynote Speaker

- 13:50 Paper 88 J. PILLING, Michigan Technological University
Diffusion Bonding in Superplastic Materials

Keynote Speaker

- 14:25 Paper 89 P.-J. WINKLER, MBB GmbH
Diffusion Bonding and Combined SPF
- 15:00 Paper 90 HUANG YAN and MA LONGXIANG, Northeast University of Technology
A Dynamic Model for Diffusion Bonding of Metals
- 15:20 Paper 91 YASUNORI SAOTOME, Gunma University and NOBUHIRO IGUCHI, Waseda University
Effects of Transformation Superplasticity on the Early Deformation Process of the Solid State Bonding in Pure Iron
- 15:40 Break
- 15:55 Paper 92 J. KENNEDY, Grumman Corporation
Diffusion Bonding and Superplastic Forming of 7475 Al Alloy
- 16:15 Paper 93 D. S. McDARMAID and P. G. PARTRIDGE, Royal Aircraft Establishment
Mechanical Properties of Ti and Al Alloys after Superplastic Deformation
- 16:45 Paper 94 ZHANG DIXIANG, Radio Manufacture Factory
The Application of Superplastic Forming for Making Plastic Injection Mould
- 17:05 Paper 95 MITSUJI HIROHASHI and HIROSHI ASANUMA, Chiba University
Combined Extrusion of Superplastic Al-Zn System Alloys

17:25 Paper 96 YANG YONGCHUN, Beijing Research Institute of Mechanical and Electrical Technology
Superplastic Behaviour of Die Steel 4Cr-3Mo-3W-2V and Application

WEDNESDAY, AUGUST 3

19:00 No-Host Social on the Terrace (weather permitting)

19:30 - 21:00 Salmon Banquet on the Terrace (weather permitting)

Purchase tickets for spouse and guests by August 1.

THURSDAY, AUGUST 4

SESSION VIII: DESIGN CONCEPTS and FUTURE DIRECTIONS

Chair: Neil E. Paton, Rockwell International, U.S.A.

Keynote Speaker

8:00 Paper 97 HAI JINTAO, DAI JILIN, CHEN SANSHAN, Beijing Research Institute of Mechanical and Electrical Technology; Z. R. WANG AND ZHANG KAIFENG, Harbin Institute of Technology
Development of Superplastic Technology in China

Keynote Speaker

8:35 Paper 98 R. RAJ, Cornell University
Mechanisms of Superplastic Deformation in Ceramics

9:10 Paper 99 D. M. WARD, Incoform Limited
Forming Non-superplastic Materials with Superplastic Membranes

9:30 Paper 100 BRUNO ROLLAND, Avions Marcel Dassault - Breguet Aviation
SPF-DB Applications for Military Aircraft

9:50 Break

10:10 Paper 101 H. NISHIMURA, S. WAKAYAMA, H. YAMAMOTO, S. YAMAGISHI, Toyko Metropolitan University
Fabrication of Fiber Reinforced Metal Using Superplastic Metal Powder as Matrix

10:30 Paper 102 FUMIHIRO WAKAI, Government Industrial Research Institute
Superplasticity of ZrO₂ Toughened Ceramics

10:50 Paper 103 B. KELLETT, P. CARRY and A. MOCELLIN, Ecole Polytechnique de Lausanne
Extrusion of Tet-ZrO₂ at Elevated Temperatures

11:10 Paper 104 T. HERMANSSON, Chalmers University of Technology, P. LAGERLÖF, Case Western Reserve University and G. DUNLOP, Chalmers University of Technology
Superplastic Deformation OF Y-TZP ZrO₂

11:30 Paper 105 Y. MUTOH, M. KOBAYASHI, Technological University of Nagaoka, Y. MAE and K. TOYOFUKU, Mitsubishi Metal Corp.
Post-SPF Fatigue Properties in Ti-6Al-4V Alloy

- 11:50 Paper 106 G. W. HUGHES, S. H. JOHNSTON, and B. GINTY, British Aerospace Public Limited Company
The Manufacture of SPF Military Aircraft Doors in Al Alloy
- 12:10 Paper 107 H. E. FRIEDRICH, M. KULLICK and R. FURLAN, MBB GmbH
SPF/DB on the Way to the Production Stage for Ti and Al Applications Within Military and Civil Projects
- 12:30 - 1:30 Lunch in San Juan Ballroom.
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THURSDAY, AUGUST 4

12:45 - 6:50 OPTIONAL TOUR TO BOEING AIRCRAFT ASSEMBLY PLANT in Everett

Bus departs promptly at 12:50.

HAVE A NICE TRIP HOME -- THANK YOU FOR COMING!

APPENDIX B

LIST OF ATTENDEES

**International Conference on Superplasticity
and Superplastic Forming**

**International Conference on Superplasticity
and Superplastic Forming
Blaine, Washington, U. S. A.
August 1-4, 1988**

Suphal Agrawal
Northrop Aircraft Division
Hawthorne CA

Rodney Bahr
Boeing Military Airplanes
Wichita KS

Eric Barta
Boeing Commercial Airplanes
Seattle WA

Thomas Bieler
Univ of California at Davis
Davis CA

Jeanine Brantingham
RMI Company
Niles OH

Claude Carry
Polytech Federale de Lausanne
Lausanne Switzerland

Naman Chandra
Florida State University
Tallahassee FL

Atul Chokski
Univ of California at Davis
Davis CA

Peter Comley
Murdock Inc.
Compton CA

Jianzhong Cui
Northeast Univ of Technology
Shenyang China

Richard Delagi
Texas Instruments Incorporated
Attleboro MA

Gordon Dunlop
Chalmers Univ of Technology
Goteborg Sweden

Beverly Ash
Rockwell International
Canoga Park CA

A.J. Barnes
Superform USA
Riverside CA

Bernard Baudalet
Inst. Nat'l Polytech de Grenoble
Saint Martin D'Herès France

Javier Bonet
University College of Swansea
Swansea West Glam, Wales

J. Pierre Brunet
Superform USA
Riverside CA

Logan Casteel
Superform USA
Riverside CA

Wonjib Choi
RIST
Pohang Korea

Ye Chou
Lehigh University
Bethlehem PA

Roy Crooks
Rockwell Int'l Science Center
Thousand Oaks CA

Sheldon Cytron
U.S. Army ARDEC
Dover NJ

Kishore Desai
Chem-Tronics
El Cajon CA

Barry Dunwoody
Superform Metals Limited
Worcester England

Nicolay Dyulgerov
Bulgarian Academy of Sciences
Sofia Bulgaria

David Edmonds
University of Oxford
Oxford England

Philippe Fernandez
Alusuisse
Neuhausen Am Rheinfall SWITZERLAND

John Fowler
Rolls Royce
Colne Lancashire, England

Norio Furushiro
Osaka University
Suita Osaka, Japan

Ramon Goforth
Texas A & M University
College Station TX

Alfred Goldberg
Lawrence Livermore Nat'l Lab
Livermore CA

Howard Hamilton
Washington State University
Pullman WA

Thomas Hermansson
Chalmers Univ of Technology
Goteborg Sweden

Mitsuji Hirohashi
Chiba Univeristy
Chiba Japan

Gareth Hughes
British Aerospace
Lancashire England

Heinz Jaeger
Hoogovens Aluminium GMBH
Koblenz West Germany

Oskar Kaibyshev
USSR Academy of Sciences
Khalturina Ufa, USSR

Horst deLorenzi
General Electric Corporation
Schenectady NY

Allison Evans
General Electric Aircraft
Cincinnati OH

Daniel Ferton
Cegeedur Pechiney
Voreppe France

Roberto Furlan
Messerschmitt-Boelkow-Blohm
Munche West Germany

Amit Ghosh
Rockwell Int'l Science Center
Thousand Oaks CA

Philippe Goin
Alsthom-ACB
Nantes France

Roger Grimes
British Alcan Aluminium
Banbury Oxon, England

Charles Heikkenen
General Dynamics
Fort Worth TX

Kenji Higashi
Osaka University
Sakai Osaka, Japan

Friedrich Horst
Messerschmitt-Bolkow-Blohm
Augsburg West Germany

Susan Hurd
Lawrence Livermore Nat'l Lab
Livermore CA

Bernt Jaensson
Saab-Scania AB
Linkoping Sweden

Stan Kan
L & F Industries
Huntington Park CA

Bruce Kellett
Polytech Federale de Lausanne
Lausanne Switzerland

Erzsebet Kovacs-Csetenyi
Aluterv-Fki, Hungalu Centre
Budapest Hungary

Manfred Kullick
Messerschmitt-Bolkow-Blohm
Munchen West Germany

Stuart Lengel
Parker Metal Bellows
Moor Park CA

Michael Luton
Exxon Research & Engineering
Annandale NJ

Nancy Mack
Washington State University
Pullman WA

Murray Mahoney
Rockwell Int'l Science Center
Thousand Oaks CA

Kenji Matsuki
Toyama University
Toyama Japan

Merrilea Mayo
Sandia National Laboratories
Albuquerque NM

Yoshinobu Motohashi
Ibaraki University
Hitachi Ibaraki, Japan

Gollapudi Murty
Indian Institute of Technology
Kanpur India

Takayuki Nagano
Suzuki Motor Co Ltd
Takatsuka Hamamatsu Japan

Hisashi Nishimura
Tokyo Metropolitan University
Tokyo Japan

Masaru Kobayashi
Technical University of Nagaoka
Nagaoka Japan

Isao Kuboki
Ibaraki University
Hitachi-Shi Ibaraki, Japan

Jean-Louis Lebrun
ENSAM
Paris France

Huang Liping
Shanghai Iron & Steel Res Inst
Shanghai China

Yan Ma
University of S. California
Los Angeles CA

Yoshiharu Mae
Mitsubishi Metal Corp
Ohmiya Saitama, Japan

Raj Malik
Parker Metal Bellows
Moor Park CA

George Mayer
Institute for Defense Analyses
Alexandria VA

Terry McNelley
Naval Postgraduate School
Monterey CA

Amiya Mukherjee
Univ of California at Davis
Davis CA

Yoshiharu Mutoh
Nagaoka University of Technology
Nagaoka Japan

Herman Nied
General Electric
Schenectady NY

William Nix
Stanford University
Stanford CA

Hiroaki Ohsawa
Hosei University
Kaganei Tokyo, Japan

Kuniaki Osada
Nippon Yakin Kogyo Co
Kawasaki Japan

Peter Partridge
Royal Aircraft Estab
Farnborough Hants England

Lynn Phillips
LTV, Aircraft Products Group
Dallas TX

Ron Rae
Mal Tool & Engineering
Manchester CT

Ricky Ricks
Alcan International Ltd
Banbury England

Robert Ringrose
Titanium International Ltd
West Midlands England

Alan Rosenstein
AFOSR/NE, Bolling A.F.B.
Washington D.C.

Yasunori Saotome
Gunma University
Kiryu Gunma, Japan

Peter Schepp
Sulzer Brothers Ltd
Winterthur Switzerland

Frank Scrima
L & F Industries
Huntington Park CA

Oleg Sherby
Stanford University/LLNL
Livermore CA

Takuji Okabe
Kure Nat'l College of Technology
Kure Japan

Chris Owen
Alcoa
Bettendorf IA

Neil Paton
Rockwell International
Canoga Park CA

John Pilling
Michigan Tech University
Houghton MI

Rishi Raj
Cornell University
Ithaca NY

Norman Ridley
University of Manchester
Manchester England

Bruno Rolland
Avions Marcel Dassault
Saint Cloud France

Daniel Sanders
The Boeing Company
Seattle WA

Eiichi Sato
Institute of Space & Astro Sci
Kanagawa Japan

Dick Schwalie
General Dynamics
Fort Worth TX

Parvin Shariat
Northrop University
Los Angeles CA

Steven Speaker
General Dynamics
Fort Worth TX

Ivan Spirov
Bulgarian Academy of Sciences
Sofia Bulgaria

Michael Stowell
TI Research
Saffron Walden Essex, England

Richard Todd
Oxford University
Oxford England

Tibor Turmezey
Aluterv-Fki, Hungalu Centre
Budapest Hungary

Fumihiro Wakai
Nagoya Industrial Research Inst.
Nagoya Japan

Bennie Ward
Reynolds Metals
Richmond VA

Don Weisert
Ontario Technologies Corp
Vista CA

David Wilkinson
McMaster University
Hamilton Ontario Canada

Peter-Jurgen Winkler
Messerschmitt-Boelkow-Blohm
Munchen West Germany

Richard Wood
University College of Swansea
Swansea West Glam, Wales

Wang Yanwen
Beijing Research Institute
Beijing China

James Story
Alcoa Laboratories
Alcoa Center PA

Edmund Ting
Grumman
Bethpage NY

Gabriel Torres Villasenor
Inst de Investigaciones en Mat.
Mexico D.F. Mexico

Jeffrey Wadsworth
Lockheed Missiles & Space Co
Palo Alto CA

Shuichi Wakayama
Tokyo Metropolitan University
Setagayaku Tokyo, Japan

David Ward
Incoform Bramah Ltd
Sheffield England

Adrian Wilkinson
The Boeing Company
Seattle WA

Dave Willis
Esco Corporation
Portland OR

Jerry Wittenauer
Sulzer Brothers Ltd
Winterthur Switzerland

Michio Yamazaki
Nat'l Research Inst for Metals
Tokyo Japan

Min Zhao
Harbin Institute of Technology
Harbin China

INTERNATIONAL CONFERENCE ON
SUPERPLASTICITY AND SUPERPLASTIC FORMING

Supplemental Roster

Werner Beck
MBB
Bremen, F.R.Germany

Gueozyui Botchvaz
Institute of Light Alloys
Moscow, U.S.S.R.

Alexandre Chadsky
Institute of Light Alloys
Moscow, U.S.S.R.

Atul Chokshi
University of Calif.-Davis
Davis, CA

Alberto M. Correa-Alvarez
Zinalco Extrusions
Mexico City, Mexico

Eugueni Gribanov
USSR State Committee for Science
Moscow, U.S.S.R.

Stephen J. Hales
Naval Postgraduate School
Monterey, CA

Syed M. Kadri
McDonnell Douglas Aircraft Co.
Long Beach, CA

James R. Kennedy
Grumman Corporation
Bethpage, NY

Matthew Kistner
The Boeing Co. - Aerospace
Seattle, WA

Chuck S. Lee
McDonnell Douglas Astronautics Co.
Huntington Beach, CA

T.G. Nieh
Lockheed
Palo Alto, CA

Ilia Novikov
Moscow Steel and Alloys Institute
Moscow, U.S.S.R.

Burkhard Plege
Dornier GmbH
Friedrickshafen, W. Germany

Nikolai Rakhmanov
Metallurgical Plant
Stupino, U.S.S.R.

Oleg Smirnov
Moscow Steel and Alloy Institute
Moscow, U.S.S.R.

Doraiswamy Viswanathan
Anna University
Madras, India

Zhongren L.R. Wang
Harbin Institute of Technology
Harbin, China

You chang Zhao
Jiling University
Changchun, China

Naohiro Ishioka
University of Maine
Orono, Maine

Jean Van Der Sanden
Esco Europe S.A.
Frameries, Belgium