

Table of Contents

Preface

Plenary Session

Overview of Quick Plastic Forming Technology

P.E. Krajewski and J.G. Schroth

3

Superplasticity of Ultrafine-Grained Aluminum Alloy Processed by ECAP and Warm Rolling

R.K. Islamgaliev, N.F. Yunusova, M.A. Bardinova, A.R. Kilmametov and R. Valiev

13

Advanced Industrial Applications

Superplastic Forming and Foaming Process for Porous Aluminum Plates

K. Kitazono, S. Kamimura, E. Sato and K. Kuribayashi

23

Production of Ti-6Al-4V Sheets for Low Temperature Superplastic Forming

G.A. Salishchev, O.R. Valiakhmetov, W. Beck and F.H. Froes

31

Fibre Reinforced Refractory Castables :An Alternative Solution for SPF Die Manufacturing

G. Bernhart, F. Nazaret and T. Cutard

37

Superplastic Titanium Tanks for Propulsion System of Satellites

E. Sato, S. Sawai, K. Uesugi, T. Takami, K. Furukawa, M. Kamada and M. Kondo

43

The Applications of SPF/DB Combined with Welding Technologies

Z.Q. Li and X.H. Li

49

Grain Refinement and High Temperature Deformation in Friction Stir Processed Sheets of Magnesium Alloys

Y. Takayama, Y. Otsuka, T. Shibayanagi, H. Kato and K. Funami

55

Overview of FSW Project in Osaka East Urban Area Industry-Government-Academia Collaboration

M. Tsujikawa, Y. Marutani and K. Higashi

61

Mathematical Model for Super Plastic Flow in Advanced Structural Materials

J.D. Muñoz-Andrade

67

Research on the Superplastic Forming of Copper Alloy Solid-Bearing Cages Used in Railway Vehicles

Y.S. Yang, G.Q. Chen and F.X. Chen

73

Study of the Superplasticity of Copper Alloys Used for Solid Cages

F.X. Chen, H. Li, J.Q. Guo, Y.S. Yang and G.Z. Xu

79

Processing Methods

Advances in the Superplastically Formed and Diffusion Bonded Process

L.D. Hefti

87

Analysis, Planning, Modelling and Presentation of an SPF Model-Plant in Virtual Reality

W. Beck, J. Meynard, A. Ouarraoui and R. Klemkow

95

Diffusion Bonding of Aluminum Alloy Using a High-Boiling Liquid Protection

L.S. Xie and Y. Sui

101

The ASTM International Standard Test Method for Determining the Superplastic Properties of Metallic Materials

P.N. Comley

105

Tool Thermal Behavior in SPF Environment

A. Petiot and T. Favre

111

Analysis of Different Specimen Geometries for Tensile Tests in Superplastic Conditions for an Aluminium Alloy

D. Sorgente and L. Tricarico

123

Forming Limit Diagrams for AA5083 under SPF and QPF Conditions M.A. Kulas, P.E. Krajewski, J.R. Bradley and E.M. Taleff	129
Mechanisms of Microsuperplasticity J.H. Robinson, M.A. Rust and R.I. Todd	135
On the Phenomenology and Mechanics of Super Plastic Flow in Advanced Structural Materials J.D. Muñoz-Andrade	147
Superplastic Deformation Mechanism of a Zn-Al Eutectoid Alloy T. Kokubo, G. Itoh and Y. Motohashi	153
Study on the Interface Characteristic of Superplastic Diffusion Bonding Joint of Dissimilar Steels M. Wang and H.Z. Guo	157
Superplastic Forming and Diffusion Bonding for Four-Layer Sheets Structure of Nickel-Base Superalloy W.B. Han, D.Z. Wu, G.F. Wang and M.J. Tong	163
Influence of Diffusion Bonding for Superplasticity Magnesium Alloys with the Fore and Post Treatment Y.D. Yu and C.W. Wang	169
Constant-Load Tester Based on Lever-Rule and Measurement of Strain Hardening Index and Strain Rate Sensitivity Index Y.Q. Song, Z.P. Guan, M.H. Wang and Y. Liu	173

Material Processing for Superplasticity

Submicrocrystalline Structure Formation in Ti and Ti-64 Alloy by Warm “abc” Deformation S.V. Zharebtsov, S. Mironov and G.A. Salishchev	183
The Role of Nd₃Sn Phase in Superplastic Deformation of Ti-5Al-4Sn-2Zr-1Mo-0.25Si-1Nd Alloy B. Zhao, Z.Q. Li, B.Z. Bai and H.P. Guo	189
Effect of ECAP Hot Processing on Grain Refinement and Superplasticity of 1933 Aluminium Alloy H.Z. Guo, J. Zhao, S.C. Yuan, Z.L. Zhao and Z.K. Yao	193
Superplasticity in Ultrahigh Carbon (1.6 Pct C) Steel Z.L. Zhang, Y.N. Liu, J.W. Zhu and G. Yu	199
A Comparative Study on Superplasticity of Mg-Zn-Y-Zr Processed by ECAE and Hot Rolling W.N. Tang, H. Yan, R. Chen and E.H. Han	203

Superplasticity in Light Metals

Superplastic Forming of Magnesium Alloys: Production of Microstructures, Superplastic Properties, Cavitation Behaviour J.J. Blandin	211
Superplastic Deformation of Magnesium Alloy AZ31 under Biaxial Loading Condition F.K. Abu-Farha, N.A. Rawashdeh and M.K. Khraisheh	219
Biaxial Tensile Deformation Behavior and Microstructural Evolutions of Superplasticity in AZ31 Magnesium Alloy M. Noda, H. Shimizu, K. Funami and H. Mori	225
Superplasticity and Superplastic Formability of Hot-Rolled AZ31 Magnesium Alloy D.L. Yin, C.W. Wang, J.T. Wang and Y.D. Yu	231
Superplastic Behaviors of Casting AZ31 Magnesium Alloy H.B. Li, J. Zhao, J.T. Luo and M. Hang	237
SPF/DB Research in ZK60 Alloy with Gasification Agent as Pressurization Mediator Y.D. Yu, C.W. Wang and D.L. Yin	241
Research on Superplastic Forming of Supplied LY12 Aluminum Alloy for Fishing Spools Y.S. Yang, G.Q. Chen and X. Yang	245

Superplasticity in Ultrafine Grained Magnesium Alloy AZ31 Prepared by Accumulative Roll Bonding	
Q.F. Wang, X.P. Xiao, X.J. Chen and W. Chen	249

Product Design and Numerical Simulation

Finite Element Modeling of Superplastic Forming in the Presence of Back Pressure	
M. Nazzal and M.K. Khraisheh	257
Numerical Simulation of Superplastic Forming of a Magnesium Alloy Part	
Q.L. Jin, Z.P. Zeng and Y.S. Zhang	263
Effect of the Process Parameters on the Deformation during Superplastic Extrusion of Ti-6.0Al-2.0Zr-1.0Mo-1.0V Alloy	
M.Q. Li, L. Long, X.L. Li, H. Yu, C.L. Chi and G.H. Wen	269
FEM Analysis of Superplastic Forming Process for an Oval Head Shell	
X. Huang, Y.S. Zeng, B. Jiang and X.Q. Han	275
Comparative Study of Element Formulation on Simulation of Superplastic Forming	
X.F. Xu, L.M. Tang and G.Q. Tong	281
Numerical Simulation and Experimental Investigation of High Strain Rate Superplastic Forming (SPF) of Al-6Mg-0.2Sc Alloy	
M.H. Chen, Y.H. Xue, Y.L. Rui, J.H. Zhou and M. Wang	287
The Pilot Study on the Defect Prediction and Numerical Simulation in the Superplastic/Extrusion of Copper Alloy	
F.X. Chen, H. Li, J.Q. Guo and X.Z. Liu	293
Finite Element Simulation of Superplastic Isothermal Forging Process for Nickel-Base PM Superalloy	
Q.H. Li, F.G. Li, Q. Wan and M.Q. Li	297
Reproducing Kernel Particle Method Numerical Modeling of Thin Sheet Superplastic Tension Forming	
H.S. Liu, Y.Y. Yang and C.F. Li	303
Superplastic Deforming Analysis Based on Element Free Galerkin Method	
Y.Y. Yang and J. Li	309
Numerical-Experimental Characterization of a Superplastic AZ31 Magnesium Alloy	
G. Palumbo, D. Sorgente, L. Tricarico, S.H. Zhang, W.T. Zheng, L.X. Zhou and L.M. Ren	317
Strain Rate Gradient Model with Couple Stress for Micro Scale Rigid-Viscosity-Plastic Deformation	
K. Lei and K.F. Zhang	323

Mechanisms of Grain Boundary Sliding and Failure

First-Principles Calculations of Grain Boundary-Surface for Various Grain Boundaries with Different Energies in Aluminum	
T. Uesugi, Y. Inoue, Y. Takigawa and K. Higashi	331
Analysis of the Behavior of a Clad Material Al-Zinag-Al	
S.R. Casolco, J. Negrete-Sánchez, M. López Parra and G. Torres-Villaseñor	337
The Activation Energy of Superplastic Flow above the Critical Temperature for Steel CrWMn	
J.B. Wen, F.X. Chen, K.K. Zhang and Y.S. Yang	341
Scale Effects in the High Temperature Gas Pressure Forming of Electrodeposited Fine-Grained Copper Thin Sheet	
K. Lei, K.F. Zhang and M.J. Tong	347

Superplasticity in Metals

Development of Superplastic Properties in Quasi Single Phase Alloys	
R. Grimes, R.J. Dashwood, A. Dorban, M. Jackson, S. Katsas, I. Pong and G. Todd	357

High-Temperature Deformation Behavior of ELI Grade Ti-6Al-4V Alloy with Martensite Microstructure	
C.H. Park, Y.G. Ko, C.S. Lee, K.T. Park, D.H. Shin and H.S. Lee	365
Superplasticity in CP-Titanium Alloys	
X.J. Zhu, M.J. Tan and K.M. Liew	373
Microstructure Evolution of the Ti-6.62Al-5.14Sn-1.82Zr Alloy in the Superplastic Compression	
M.Q. Li, H.S. Pan and Y.Y. Lin	379
The Effects of Extrusion Ratio and Friction on Material Microstructures during Sandglass Extrusion Process	
W.L. Lu, Y. Wang and J.T. Hai	383
The Effect of Grain Size on Superplastic Deformation of Ti-6Al-4V Alloy	
W.J. Zhao, H. Ding, D. Song, F.R. Cao and H.L. Hou	387
Isothermal Compressive Superplastic Deformation and its Constitutive Equation of Structural Steel and Tool Steel	
K.K. Zhang, Y.L. Yang, J.B. Wen and H. Yu	393
Solid State Diffusion Welding by Superplastic Coordinate Deformation between Vacuum Spray Fusing Alloy G111WC and Steel Substrate	
Y.Z. Zhang, J.B. Huang, H.P. Wang and X. Lin	399
The Research on Superplasticity of Two New Ti Alloys	
Y.Q. Zhao, H.L. Qu and L.Y. Zeng	405
Superplastic Bulging Capability of Ti-6Al-4V Butt-Welded Plate by High Energy Beam Welding	
G. Wang, K.F. Zhang, W.B. Han, D.Z. Wu and C.W. Wang	411
Effect of Hydrogenation on the Microstructure during the Isothermal Compression of Ti-5.6Al-4.8Sn-2.0Zr-1.0Mo Alloy	
Y.Y. Lin, M.Q. Li, Y. Niu and W.F. Zhang	417
Influence of Deformation Heat Treatment on the Ultra-Fine Structure of Austenitic Stainless Steel	
M. Wang and H.Z. Guo	421
Superplastic Forming and Thickness Distribution of Ti6Al4V Alloy Denture Base	
S.S. Jiang and K.F. Zhang	427
Superplastic Behavior and Microstructural Evolution of GH4169	
H.Y. Xu, Z.Q. Li and H.P. Guo	433

Superplasticity in Intermetallics

Superplastic Properties and Superplastic Forming/Diffusion Bonding of γ-TiAl+α_2-Ti₃Al Sheet Materials	
R.V. Safiullin, R.M. Imayev, V.M. Imayev, W. Beck, F.H. Froes and G.A. Salishchev	441
Superplastic Properties of γ+α_2 Titanium Aluminide Alloy Ti-43Al-(Nb,Mo,B) in Cast + Post-Solidification Heat Treated Condition	
V.M. Imayev, R.M. Imayev, T.G. Khismatullin and G.A. Salishchev	447
Heat Treatment of Ti₂AlNb Intermetallic and its Superplastic Properties	
H.P. Guo and Z.Q. Li	453
Investigation of Compression Deformation Behavior and Microstructure Evolution of NiAl-Cr (Mo)-Hf Alloy at Elevated Temperature	
G.Q. Chen, S.H. Ji, W.L. Zhou, C.W. Wu, J.T. Guo and Z.H. Huang	457
A Study on Superplastic Behavior and Microstructural Evolution of an Isothermally Forged TiAl Based Alloy	
H. Ding, D. Song, Z.Q. Pan, C.P. Zhang and J.Z. Cui	463
Synthesis and Superplastic Deep Drawing of TiAl Alloy	
W.B. Han, Z.J. Wang, D.Z. Wu and G.F. Wang	467

Superplasticity in Ceramics

Microstructures after Bending Deformations to Fracture of Zr Ion Irradiated Superplastic Ceramic 3Y-TZP	
T. Sakuma, Y. Motohashi, T. Shibata, K. Sawa and M. Ishihara	475
Superplastic Phenomenon in Sc₂O₃ Doped Zirconia Polycrystals to be Used for SOFC	
Y. Motohashi, H. Ishimura, Y. Kobayashi and T. Sakuma	481
Superplastic Sinter-Forging of Fine-Grained Si₃N₄-Si₂N₂O Composite at Low Temperature	
J.T. Luo and Q. Zhang	487
Fabrication of Nanocrystalline Superplastic ZrO₂ Ceramics	
K. Morita, K. Hiraga, B.N. Kim, H. Yoshida and Y. Sakka	491
Superplastic Extrusion of Nano-Structured Si₂N₂O-Sialon	
J.T. Luo, Q. Zhang and H.B. Li	497
Superplastic Extrusion of Ultra Fine-Grained 3Y-TZP/Al₂O₃ Ceramic for Turbine Disk	
F. Wang, K.F. Zhang and W.B. Han	501
Tribology in Superplastic Forming Processing of 3Y-TZP/Al₂O₃ Ceramic at Elevated Temperatures	
F. Wang, K.F. Zhang and W.B. Han	507
Superplastic Joining of TZP Enhanced by Titania-Doping in the Insert Material	
Y. Takigawa, H. Takadama and K. Higashi	513

Superplasticity in Nanostructured Materials

Superplastic Deformation Behavior of Electrodeposited Nickel Matrix Nanocomposite	
K.C. Chan, C.L. Wang, G.F. Wang and K.F. Zhang	521
Effect of Superplastic Deformation on the Properties of Zirconia Dispersed Alumina Nanocomposite	
G.Q. Chen, S.H. Sui, X.D. Wang and W.B. Han	527
Numerical Simulation and Experimental Research on Superplasticity of Ceramic/Ceramic Laminated Composite	
G.F. Wang, D.Z. Wu, C.W. Wang and W.B. Han	533
Superplasticity and Microstructure Evolution of Electrodeposited Nanocrystalline Nickel	
S. Ding, K.F. Zhang and G.F. Wang	539
Superplastic Micro Deep Drawing of Fine-Grained Nickel at Elevated Temperatures	
S. Ding, K.F. Zhang and G.F. Wang	545

Superplasticity in Bulk Metallic Glasses

Rheological Analogies of Superplastic and Viscous-Plastic Materials Flow	
O.M. Smirnov, V.K. Portnoy, M.A. Tsepin and N.L. Lissunets	553
Homogeneous Flow of In Situ Bulk Metallic Glass Matrix Composite	
K.C. Chan, Q. Chen and L. Liu	561
Deformation Behavior of Zr-Based Metallic Glass and Microforming of Microgears	
X.L. Guo, D.B. Shan, B. Guo, C.J. Wang, J. Zhou and Z.H. Xu	569
Gas Pressure Forming of Amorphous Fe₇₈Si₉B₁₃ Alloy	
X.F. Li, K.F. Zhang, W.B. Han and G.F. Wang	575

High Strain Rate and Low Temperature Superplasticity

Application of High-Strain-Rate Superplastic Zn-Al Alloy to Seismic Dampers and its Optimised Shape Design	
A. Kushibe, Y. Takigawa, K. Higashi, K. Aoki, K. Makii and T. Takagi	583
Low Temperature Superplasticity of Titanium Alloy Processed by Thermohydrogen Treatment	
Z.Q. Li, H.L. Hou and Y.Q. Wang	591
Superplastic Flow of Silicon Nitride-Based Nanocomposite at High Strain Rates	
K. Chihara, Y. Shinoda, T. Akatsu and F. Wakai	597

Low Temperature Superplasticity and Intragranular Misorientation in Severely Rolled Sheets of Al-4.5%Mg-0.7%Mn Based Alloys	
Y. Takayama, H. Ochiai, N. Furushiro, H. Kato and H. Watanabe	601
Superplasticity of Nanostructured Nickel Alloy and Composite Fabricated by Electrodeposition	
G.F. Wang, S. Ding, C.L. Wang and T.G. Nieh	607
 Microstructural Control and Microstructural Evolution during Superplastic Deformation	
High Resolution Surface Studies of Superplastic Deformation	
M.A. Rust and R.I. Todd	615
Cavitation Behavior of Ultra-Fine Grained Ti-6Al-4V Alloy Produced by Equal-Channel Angular Pressing	
Y.G. Ko, Y.N. Kwon, J.H. Lee, D.H. Shin and C.S. Lee	621
The Effect of Strain Rate History on the Dynamic Grain Growth Behaviour of AA 5083	
B. Zhang, P.S. Bate and N. Ridley	627
Cavitation Behavior of Fine-Grained 1420 Al-Li Alloy during Superplastic Deformation	
J. Shao, H.P. Guo, Z.Q. Li and X.Q. Han	633
Study on Superplastic Grain Growth Model and Dynamic Simulation	
T.R. Zhou, L.J. Wang and C.H. Xiong	639
Cavity of Al-Cu-Mg Alloy during Superplastic Deformation	
M. Wang, H.Z. Guo and Y.J. Liu	645
Microstructure Evolution and Mechanical Properties of Mg Alloy AZ31D Processed by Equal Channel Angular Extrusion	
Y.S. Zhang, Z.P. Zeng, X.F. Liu and Q.L. Jin	651