TABLE OF CONTENTS

Paper Number

Preface v

Steering Committee vii

International Organizing and Review Committee vii

Dedication ix

Table of Contents xi

Solidification Modeling, Past and Present 1
M.C. Flemings (Keynote)

MOLD FILLING

Numerical Recipes for Mold Filling Simulation 17
D. Kothe, D. Juric, K. Lam, and B. Lally (Keynote)

Application of a Parallel Algorithm to 3-D Mold-Filling and Solidification Processes 29
M. Audet, J-F. Hetu, and F. Ilinca

Mold Filling Simulation with Non-Structured Meshing 37
I. Ohnaka, R. Kanatani, and J.D. Zhu

Modeling of Cold Shut during Mold Filling 45
Z.A. Xu and F. Mampaey

Lost Foam Casting Simulation with Defect Prediction 51
C.W. Hirt and M.R. Barkhudarov

Experimental and Numerical Investigation of Mold Filling 59
R.M. McDavid and J.A. Dantzig

Investigation of Running Systems for Grey Cast Iron Camshafts 67
M.R. Jolly, S.W. Wen, A. Lapish, N.D. Butler, M. Wickens, and J. Campbell

Prediction of Heat Loss in Filling Channel 77
M. Wu and P.R. Sahm

Modeling of Mold Filling and Solidification Sequences in the Permanent Mold Casting Process with an Automated Water Cooling System 85
Y.C. Lee, S.M. Lee, Q.M. Chang, J.K. Choi, and C.P. Hong

A 3D Finite Element Model Applied to Complex Thin Wall Cavity Filling in Die Casting 93
D.M. Gao

Prediction of Cold Shuts Using an Unstructured Mesh Finite Volume Code..... 101
G.J. Moran, S.M. Bounds, K.A. Pericleous, and M. Cross

A Fast and Practical Algorithm for Three Dimensional Computer Simulation of Mold Filling 109
J.D. Zhu, I. Ohnaka, and Y. Ageta

Improvement of Computational Efficiency of Numerical Simulation of Mold Filling of Casting 117
W. Qiu, L.R. Jia, S.M. Xiong, and B.C. Liu

Numerical Simulation of Mold Filling Based on van Leer Approximation 125
B-J. Yang, L-N. Cai, and J-Y. Su

The Gas-Liquid Interface Tracking Using Level Set Approach for Die Casting Application ... 133
H. Wei and Y.S. Chen

Horizontal Mould Filling of a Thin Wall Aluminium Casting 141
R. Van Tol, L. Katgerman, and H.E.A. Van den Akker

A 3-D Mathematical Model for the Flow Pattern of Molten Metal in the Shot Sleeve of a Cold Chamber Die Casting Machine and Its Experimental Verification..... 149
J-H. Kuo, S-M Pan, and W-S. Hwang

MICROSEGREGATION

Analysis of Solidification Path and Microsegregation in Multicomponent Alloys 159
W.J. Boettinger, U.R. Kattner, and D.K. Banarjee (Keynote)

An Overview on Premises for the Technical Applicability of Solidification Micromodelling . 171
M. Rettenmayr and H.E. Exner

A 2D Combined Model of Dendrite Evolution/Solute Redistribution/Post-Solidification Solutioning in Equiaxed Grains 179
S.G.R. Brown and J.A. Spittle

Macroscopic Modeling of the Microstructural Evolution in Castings Using Thermodynamic Formulated Phase Diagrams 187
K. Greven, M. Fackeldey, A. Ludwig, T. Kraft, M. Rettenmayr, and P.R. Sahm

Alstruc-Simulation of the Effects of Minor Alloying Elements on the Cooling Curves and the Microstructure of A1Si-Foundry Alloys 195
A.L. Dons, S. Brusethaug, and J. Voje

An Approximate Method for Coupling Microscopic and Macroscopic Simulations Using Calculated Phase Diagrams 203
T. Kraft, H. Liang, and Y.A. Chang

Modelling of Solidified Structure of Ternary Aluminium Alloys 211
A. Roósz, J. Szoke, and I. Kuti

A Mathematical Model for Microsegregation in Rapidly Solidified Alloys 219
G.-X. Wang, V. Prasad, S. Sampath, and H. Herman

Calculation of Microsegregation for the Directionally Solidified Superalloy CMSX 4 Using a Pseudo 2-Dimensional Model 227
U. Grafe, D. Ma, A. Engström, and S.G. Fries

Numerical Approach of the Segregation Occurring in Alloys Solidification 235
O. Bertrand and E. Arquis

MACROSEGREGATION

Recent Progress in Understanding and Prediction of Macro and Mesosegregations 245
H. Combeau, B. Appolaire, and G. Lesoult (Keynote)

Macrosegregation Formation During Solidification of Complex Steel Castings: 3-D Numerical Simulation and Experimental Comparison 257
M.C. Schneider, C. Beckermann, D.M. Lipinski, and W. Schaefer

Semi-Analytical Models of Segregation Processes 265
V. R. Voller

Measurements and Modelling of Surface Macrosegregation in DC Casting 273
H.J. Thevik, A. Mo, A. Hakonsen, S. Benum, E.K. Jensen, and B-R. Henriksen

Analysis of Heat Transfer and Macrosegregation in Horizontal Strip Casting 281
A.V. Kuznetsov

Macroscopic Modeling of Marangoni Flow and Solute Redistribution During Laser Welding of Steel 289
G. Ehlen, A. Schweizer, A. Ludwig, and P.R. Sahm

Numerical Modeling of Macrosegregation During Ingot Casting in the Plasma Arc Melting Process 297
S. Sundarraj, L. Nastac, J. Pang, and K.O. Yu

Macrosegregation Observed in an A356 Alloy Part Manufactured by Squeeze-Casting Process 305
J-L. Doudoux, N. Hueber, A. Remy, and T. Callais

Solute Diffusion During the Eutectic Reaction in Micro-Macrosegregation Modelling 313
H. Combeau and A. Mo

Analytical Expressions for the Inverse Segregation with Finite Solute Diffusion in the Solid Phase 321
E. Haug and H.J. Thevik

3D Modelling of Heat, Momentum and Solute Transport in Laser Surface Alloying 329
N. Pirch, E.W. Kreutz, X. He, and B. Mordike

A Comparison Between Experiments and Empirical Criteria Predicting A-Type Segregations and Microporosity 337
I. Vannier, C. David, H. Combeau, and G. Lesoult

Effect of Section Changes on Microstructure and Segregation in Directionally Solidified Castings 345
D. Xu, X. Wang, Q. Li, and R.D. Pehlke

Numerical Determination of the Permeability Tensor in a Columnar Dendrite Mushy Zone ... 353
B. Goyeau, T. Benihaddadene, D. Gobin, and M. Quintard

GRAIN STRUCTURE MODELING

Modeling of Dendritic Grain Structures 363
Ch.-A Gandin, T. Jalanti, and M. Rappaz (Keynote)

Numerical Modeling of the Columnar to Equiaxed Transition in Continuous Casting of Steel 375
M. M'Handi, M. Bobadilla, H. Combeau, and G. Lesoult

Modeling of Deflected Columnar Grains Solidified in Flowing Melt 383
S.Y. Lee, S.M. Lee, and C.P. Hong

Predicting the Columnar-to-Equiaxed Grain Transition in Gas Tungsten Arc Welds in Aluminum-Copper Alloys 391
J. Clarke, D.C. Weckman, and H.W. Kerr

Grain Structure of the Laser Beam Welds: Undergoing Planar Solidification Mode 399
V.V. Ploshikhin and H.W. Bergmann

Prediction of Stray Crystal Formation During Solidification of Dendritic Alloys 407
A. de Bussac and Ch.A. Gandin

Experimental Study of the Columnar to Equiaxed Transition in a Refined AL-4WT%CU Alloy Under Diffusive Transport Conditions 415
M.D. Dupouy, D. Camel, F. Botalla, J. Abadie, and J.J. Favier

Effects of Grain Transport on Columnar to Equiaxed Transition in Dendritic Alloy Solidification 425
J.W. Gao and C.Y. Wang

A 3D CAFE Model for the Prediction of Solidification Grain Structures 433
J.-L. Desbiolles, Ch.-A. Gandin, J.-F. Joyeaux, M. Rappaz, and Ph. Thévoz

CAST IRON STRUCTURE

Modelling of Microstructure Formation in Cast Iron 443
I.L. Svensson and M. Wessén (Keynote)

Prediction of Room Temperature Microstructure and Mechanical Properties in Iron Castings 455
A. Catalina, X. Guo, D.M. Stefanescu, L. Chuzhoy, M.A. Pershing, and G.L. Biltgen

Predicting Gray Iron Microstructure and Mechanical Properties Using Solidification Simulation 463
B. Leube, L. Arnberg, and R. Mai

Numerical Simulation of Microstructural Evolution of Nodular Cast Iron-For the Case of Automobile Crankshaft by the Croning Process 471
S.-M. Yoo, A. Kleine, A. Ludwig, and P.R. Sahm

Physical Modelling of the Solidification of Spheroidal Graphite Cast Irons: Revisitation of the Coupled Zone Concept 479
G. Lesoult, M. Castro Roman, and J. Lacaze

Prediction of the Solidification Microstructure of Hypo- and Hypereutectic Spheroidal Graphite Cast Irons 487
M. Castro Roman, A. Charbonnier, V. Gerval, J. Lacaze, S. Langlois, G. Lesoult, T. Margaria, and R. Siclari

Physical Simulation of Solidification in a Hot Stage Microscope Applied in the Modeling of Ductile Iron Castings 495
R. Aagaard and K.A. Thorsen

Natural Convection Effects in Cast Iron 503
F. Mampaey and Z.A. Xu

Influence of Copper, Tin and Manganese on Ferrite Formation in Ductile Iron: Experiments, Models and Simulation 511
M. Wessén

DIRECT MICROSTRUCTURE SIMULATION

Direct Numerical Simulation of Solidification Structure Using the Phase Field Method 521
I. Steinbach and G.J. Schmitz (Keynote)

Adaptive Grid Methods in Solidification Microstructure Modeling..... 533
N. Provatas, N. Goldenfeld, and J.A. Dantzig

An Anisotropic Multiphase-Field Model: Interfaces and Junctions 541
B. Nestler and A.A. Wheeler

Microstructural Development in Undercooled Germanium 549
D. Li

Simulations of Binary Eutectic Microstructures Using the Multi-Phase-Field Method 557
M. SeeBelberg and J. Tiaden

Modeling of Convection-Influenced Coarsening of a Binary Alloy Mush Using the Phase-Field Method 565
H.-J. Diepers, C. Beckermann, and I. Steinbach

Three-Dimensional Modeling of Equiaxed Dendritic Growth on a Mesoscopic Scale..... 573
L. Steinbach, B. Kauerauf, C. Beckermann, J. Guo, and Q. Li

Solidification in Heterogeneous Media: A Numerical Study at a Small Scale..... 581
E. Arquis and J.-P. Caltagirone

Numerical Simulation of Dendrite Morphology and Grain Growth with Modified Cellular Automaton..... 589
U. Dilthey and V. Pavlik

The Influence of Convection on Dendrite Tip Shape Morphology.....597
J.C. LaCombe, M.B. Koss, A.Lupulescu, L.A. Tennenhouse, and M.E. Glicksman

Direct Numerical Simulation of Solidification Microstructures Affected by Fluid Flow 605
D. Juric

Phase Field Simulation of Dendritic Growth with Convection 613
X. Tong, C. Beckermann, and A. Karma

HEAT AND FLOW MODELING OF CONTINUOUS CASTING PROCESSES

The Modelling of Transient Heat and Fluid Flows in the Start-Up Phase of the DC Casting Process 623
B.R. Henriksen, E.K. Jensen, and D. Mortensen

Experimental and Numerical Determination of Crater End in Continuous Casting of Steel.....631
H. Kytönen, M. Tolvanen, S. Louhenkilpl, and L. Holappa

The Formation of Oscillation Marks in Continuous Casting of Steel.....639
H. Steinrück, C. Rudischer, and W. Schneider

Implicit Analysis of Filling and Solidification During the Start-Up Stage of DC Casting Process 647
B. Minaie and S. Peng

Internal Flow and Shell Solidification in Horizontal Continuous Casting Processes.....655
V. Noshadi, W. Schneider, and A.V. Kuznetsov

Heat Transfer and Solidification in Horizontal Strip Casting.....663
M. Digruber, S. Haas, and W. Schneider

Segregation Effects in Rapidly Solidified SiC Reinforced Aluminium Composites.....671
L. Katgerman, N.J. Fei, and W.H. Kool

Fluid Flow Aspects of Metal Delivery Systems for the Casting of Steel and Aluminum 679
W.K. Jones, Jr., D. Xu, and J.W. Evans

HEAT AND FLOW MODELING OF LASER, MELTING, AND WELDING PROCESSES

A Vorticity-Based Model for Turbulence in Weld Pools 689
K. Hong, A.B. Strong, and D.C. Weckman

Finite Element Simulation of Solidification Process of Metallic Powders in Laser Rapid Prototyping 697
M. Shiomi, A. Yoshidome, K. Osakada, and F. Abe

Modeling of Flotation Process in Aluminum Melt Treatment 705
M. Maniruzzaman and M.M. Makhlouf

Analysis of Ripple Formation in Single Crystal Spot Welds 713
M. Rappaz, D. Corrigan, and L.A. Boatner

Experiments on Phase Change Processes Controlled by Convective Heat and Mass Transfer . 721
S. Mergui, B. Feroual, D. Joly, C. Bénard, and D. Gobin

STRESS AND DISTORTION

A Thermo-Elasto-Visco-Plastic Analysis for Determining Air Gap and Interfacial Heat Transfer Coupled with the Lewis-Ransing Correlation for Optimal Feeding Design 731
R.S. Ransing and R.W. Lewis

A Numerical Mechanical Coupling Algorithm for Deformable Bodies: Application to Part/Mold Interaction in Casting Process 739
O. Jaouen and M. Bellet

Coupled Thermo-Mechanical Simulation of Industrial Solidification Processes 747
M. Cervera, C. Agelet de Saracibar, and M. Chiumentl

A Three Dimensional Finite Volume Approach to the Thermo-Mechanical Modelling of the Shape Casting of Metals 755
G.A. Taylor, C. Bailey, and M. Cross

Stress/Strain Modeling of Casting Processes in the Framework of the Control Volume Method 763
J. Hattel, J. Thorborg, and S. Anderson

Study on Residual Stress of Cylinder Block Casting by Using an Integrated FDM/FEM System 771
Y. Chen, J.W. Kang, and B.C. Liu

Analysis and Validation of Multi-Pass Girth Welds in Pipes 779
A.R. Ortega, J.J. Dike, J.F. Lathrop, C.H. Cadden, D.R. Folk, and J.E. Robles

Computational Modelling of Interacting Phenomena in the Shape Casting Process 787
M. Cross, C. Bailey, K.A. Pericleous, S.M. Bounds, G.J. Moran, G.A. Taylor, and K. McManus

Thermal Stress and Crack Prediction of Investment Casts Alloys 795
L.C. Wüker, M. Fackeldey, P.R. Sahm, and B.G. Thomas

Prediction of Welding Deformations by FEM Based on Inherent Strains 803
J. Wang and H. Lu

Numerical Simulation Steam Generator Repairs 811
L. Junek, V. Ochodek, and M. Slovacek

Shrinkage Prediction in the Thermomechanical Analysis of Castings 819
D. Celentano.

Computational Modelling of Mould Design in Lead Ingot Casting 827
C. Bailey

MICROPOROSITY

Phenomena Related to the Formation of Microporosity in Castings 837
D.R. Poirier (Keynote)

Prediction of Microporosity in Aluminum Alloy Castings 849
S. Viswanathan, A.J. Duncan, A.S. Sabau, and Q. Han

Finite Volume Modelling of Shrinkage Porosity Formation in Metal Casting 857
S.M. Bounds, G.J. Moran, K.A. Pericleous, and M. Cross

Modeling of Microporosity Evolution During Solidification Processes 865
J. Huang and J.G. Conley

DEFORMATION AND HOT TEARING

Isothermal Constitutive Behaviour of the Solid-Liquid Mushy Zone, Theoretical Treatment and Experimental Identification 875
C.L. Martin, D. Favier, M. Suéry, and M. Bobadilla

Study of Hot Tearing in Aluminum Alloys Using the Ring Mold Test 883
J.-M. Drezet and M. Rappaz

A Solidification Model for Use in the Prediction of Hot Tears in Castings 891
A. Ahmed and U. Chandra

Study on Stress-Strain Simulation of Cast Steel Test Bar by Rheological Model 899
J.W. Kang, Y. Chen, B.C. Liu, M.J. Jin, and H. Zoo

Modeling of Thermal Stresses Near the Liquid-Solid Phase Boundary 907
M. Diemer and D. Franke

A Measurement of Critical Strain for Internal Crack in Continuously Cast Slabs 915
K. Nakayama, M. Kinefuchi, and K. Tsutsumi

Influence of Alloying Elements and Cooling Conditions on Hot Tearing of Steel, Measured by the SSCT-Test 923
C. Bernhard, H.Moitzi, H. Hiebler, and M.M. Wolf

SEMI-SOLID PROCESSES

Modeling the Rheology of Semi-Solid Metal Alloys During Die Casting 933
C.J. Paradies, M. Rappaz, T. Imwinkelried, and J.P. Gabathuler

Numerical Modelling of Extrusion for a Semi-solid Alloy 941
F. Bay, J. Barlier, Y. Chastel, M. Bobadilla, and G. Lovato

Modeling and Experimental Control of Heat and Mass Transfer in Semi Solid DC Casting 949
U. Feurer and A. Wahlen

Modeling the Structural Parameters of Semi-Solid Cast Material (A356) 957
A. Wahlen and U. Feurer

Die Filling Studies of Aluminium Alloy AlSi7Mg0.3Sr in Its Semi-Solid State 965
F.C. Yee, S.W. Hao, X.P. Niu, and B.H. Hu

NOVEL APPLICATIONS, OPTIMIZATION AND CASTING DESIGN TOOLS

Automatic Computer Optimization of Casting Design and Casting Processes Using Evolutionary Strategies 975
J. Wolf, G. Ehlen, and P.R. Sahm

Advanced Inverse Techniques for the Design of Directional Solidification Processes 983
N. Zabaras, G.Z. Yang, and R. Sampath

An Expert System for the Design of Cooling Channels in Permanent Molds 991
T. Davis, M. Matthews, and M. Makhlouf

Reducing the Cycle Time in Die Casting Using Solidification Modelling and Optimisation Techniques 999
D.P.K. Singh, N. Palle, G.D. Mallinson, S.M. Panton, and S. Mahadeva

The Spectral Modelling of Contactless Induction Melting for Reactive Metals..... 1007
V. Bojarevics, K.A. Pericleous, and M. Cross

Modeling of Centrifugally-Cast TiC/Bronze Metal Matrix Composites 1015
H. Hao, X. Huang, L. Nastac, S. Sundarraj, and A. Simkovich

Heat Transfer Coefficients Between a Hollow Cylinder Casting and Metal Mold..... 1023
T-G. Kim, Y-S. Choi and Z-H. Lee

A Study of the Variation of Heat Transfer Coefficients in Aluminum Investment Casting..... 1031
D. O'Mahoney and D.J. Browne

The Pressure Die Casting Process: Effective Models for Boiling, Solidification and Metal Injection 1039
K. Davey, S. Hinduja, L. Rosindalf, and L.D. Clark

Water Effects and Thermal Behavior of a Sand, Thermal Properties Identification by Optimization Tools 1047
N. Hueber and Z. Ignaszak

A Critical Evaluation of Criteria Functions for Use with Shaped-Casting Modeling 1055
R.P. Taylor, J.T. Berry, and R.A. Overfelt

Numerical Analysis of Steel Solidification Using Finite Difference Method and Finite Element Method..... 1063
W. Palmiere and R.G. dos Santos

Computer Modelling of the Formation of Macro Shrinkage Cavities During Solidification..... 1071
J. Beech, M. Barkhudarov, K. Chang, and S.B. Chin

The Influence of Fluid Flow on the Last Point to Solidify in a Casting 1079
B. Minaie and V.R. Voller

Cast-Aid: A Decision Support System for Designing Castings 1087
T.J. Mileman, D. Knight, D.F. Cowell, and K.L. Preddy

Optimization Tools for Bridgman Casting Process 1095
G. Laschet, M. Schallmo, and N. Hofmann

New Developments in Green Sand Moulding of Automotive Aluminium Castings 1103
P.N. Hansen, N.W. Rasmussen, M. Wanzeck, U. Andersen, and P.L. Larsen

A Study of Neural Networks for Porosity Prediction in Aluminum Alloy 356 Castings 1111
J. Huang, J.G. Conley, and P. Callau

Application of Process Modeling to Large Titanium and Superalloy Structural Investment Castings and Wax Pattern Injection Molding 1119
D.H. Hirvo, A.M. Hines, B.A. Mueller, J. He, G.D. Morwood, and T.S. Simon

BENCHMARK EXPERIMENTS

Experimental Benchmarks - Overview 1129
B.G. Thomas

Experimental Investigation of Mold Filling in High Pressure Die Casting 1131
M. Schmid and F. Klein

Mold Filling Experiments of Cast Alloys Using Video Monitoring 1137
A. Louvo, K. Saarinen, and K. Rautama

Particle Imaging Velocimetry of the Liquid Pool During Casting of Aluminum and Steel - A Benchmark Study 1145
D. Xu, W.K. Jones, Jr., and J.W. Evans

Micro and Macrostructural Features and Heat Transfer During Plasma Melting of IN 718 ... 1161
R.M. Ward, T.P. Johnson, and M.H. Jacobs

Measurements of Temperatures on a Large Engine Block During Solidification 1175
E.P. Warnke and D. Bounin.

Measurement of Temperature, Solidification, and Microstructure in a Continuous Cast Thin Slab 1185
B.G. Thomas, R. O'Malley and D. Stone

Microstructural Evolution of a 319 Aluminum Alloy During Solidification 1201
J.W. Zindel, L.A. Godlewski, and W.T. Donlon

Variation in Temperature and Dimension During the Solidification of Nodular Graphite Iron Casting.....1209
E. Fras, W. Kapturkiewicz, H.F. Lopez, A. Bielet, A. Burbelko, and Z. Wröbel

Experiment on the Dimensional Changes of Steel Castings During Solidification.....1217
F.E. Peters and R.C. Voigt

Benchmarking Experiments for Permanent Mold Aluminum Alloy A356 Castings.....1225
J.G. Conley and J. Huang

Internal and External Porosity in Short, Medium and Long Freezing Range Aluminum Alloy Castings.....1241
Y. Li, M.R. Jolly, and J. Campbell

Subject Index..... 1255

Author Index 1263