Agenda

August 16, 2012

Continuous Casting Consortium Annual Meeting 2012

Brian G. Thomas, Director

Department of Mechanical Science & Engineering
University of Illinois at Urbana-Champaign

Objectives

- To develop computational models of continuous casting of steel and related processes
- To apply these models to problems of practical interest to the steel industry

Attendees

ABB	Martin Seden, Christer Carlsson
Baosteel:	Zengjie Fan, Ruan Xiaoming, Jian-Guo Shen, and Li Zhang
Delavan Goodrich	Alex Prociw
Tata Steel:	Gerard Stephens
Magnesita Refractories:	Bruno Ribeiro, Alessandro Prenazzi, and R.Nunnington
ArcelorMittal:	Tatha Bhattacharya, Hongbin Yin (Global R&D, E.Chicago), Rich Gass, Michael Krug, Key Robertson (Indiana Harbor), Rudolf Moravec?, Joydeep Sengupta (Dofasco)
Nucor Steel:	Ron O'Malley (Decatur, AL)
Nippon Steel:	Hideaki Yamamura, Kohichiroh Harada, Norimasa Yamasaki, and Naoki Oishi
Postech:	Seon-Hyo Kim, Seong-Mook Cho, and Hyoung-Jun Lee
POSCO:	Hee-tae Jung
SSAB:	Xiaoxu Zhao, Sunday Abraham, Rick Bodnar, Yufeng Wang
Ansys / Fluent Inc.:	Ashwini Kumar & Qida Bing
University of Illinois:	Brian G. Thomas, Joseph Bentsman, Pratap Vanka, Bryan Petrus, Rui Liu, Kun Xu, Kai Jin, Ramnik Singh, Lance Hibbeler, Yonghui Li, Pete Srisuk, A.S.M. Jonayat, Vivek Natarajan, Inwho Hwang, Brendan Joyce, Matt Zappulla.
Other CCC researchers:	Lejun Zhou, Seong-Mook Cho*, Hyung-jun Lee*, Eric Badger, Eric Eckstrum, Seid Koric, Kevin Cukierski, Zengjie Fan*.

Day 1: Morning Session

8:00am Breakfast & Introductions 2005 Mech. Eng. Lab. (Deere Pavilion)

8:05	B.G. Thomas:	Overview of Projects
2 8:15	R. Liu	Slide-gate Dithering Effect on Transient Flow & Mold Level Fluctuations
9:05	S.-M. Cho	Bubble formation, breakup and coalescence in stopper-rod nozzle flow and effect on multiphase mold flow
9:30		EMBr Effect on Mold Level Fluctuations
5 9:40	Kai Jin & Z. Fan	Mold Flow with Argon Gas, EMBr and Evaluation using Nailboard Measurements
10:00	*Break*	
10:30	Ramnik Singh	Effect of EMBr on Transient Mold Flow with DNS Modeling and Ga-In-Sn Benchmark Measurements
10:50	Lejun Zhou	Mold Flux Crystallization
11:00	ASM Jonayat	Mold Heat Transfer Using CON1D and Slag Consumption Model
11:30		Discussion of Flow Projects
12:10pm	*Lunch*	2005 Mech. Eng. Lab

Day 1: Afternoon Session

1:10	I. Hwang & L. Hibbeler	Calibration Script for CON1D
10 1:20	L. Hibbeler	Thermal Stress Analysis of Dendritic Microstructure during Solidification
1:50	B. Petrus	Control of Spray Cooling: CONONLINE Implementation Issues
2:10	K. Xu	Multiphase Model of Precipitate Formation and Grain Growth in Secondary Spray Cooling
2:45	M. Zappulla	Demo of Equilibrium Precipitation Modeling Program
3:00	*Break*	
3:30	P. Srisuk	Heat Transfer and Ideal Shrinkage for Soft Reduction Modeling
15 3:50	Y. Li	Modeling Heat Transfer in SEN during Preheating, & Cool-down
4:20	H.J. Lee	Thermal Stress Cracking of Slide Gate Plates
4:40	V. Natarajan	Control of Mold Oscillation
5:00		Group Discussion of Future Projects and Directions
5:30	Adjourn	
6:00	*Dinner*	Colonial Room, Illini Union Building (NE corner main floor)

Day 2

B.G. Thomas: 356 Mech. Eng. Bldg.
Informal discussions on future projects
(Prior appointments would be helpful)

7:00 – 8:00	ArcelorMittal – T. Bhattacharya and J. Sengupta
8:00 – 9:00	NSC – Hideaki Yamamura (early)
9:00 – 10:00	Tata – Gerard Stephens
10:00 – 11:00	SSAB – Sunday Abraham, X. Zhou, et al.
11:00 – 12:00	ABB – Martin Seden & Christer Carlsson
12:00 – 1:00pm	Baosteel – R. Xiaoming et al.
1:00 – 2:00pm	Nucor - OMalley
2:00 – 3:00pm	
3:00 – 4:00pm	

8:00 am-? *Research group: 345 Mech. Eng. Bldg.*
Informal discussions with students
Further details on current projects and software
Questions

Day 3 Magnesita – B. Ribeiro and R. Nunnington

New CCC Software

EQPrecip

CCC Precipitation Model – Equilibrium

- Standalone program to compute stable precipitates in steels,
- developed by Kun Xu,
- with user interface by Matt Zappulla
- with user-customizable database
- graphical output and excel-file output

2012 CCC Reports – Nozzle-related Behavior

Model of Gas Flow through Upper Tundish Nozzle Refractory and Initial Bubble Size
Liu, Rui, and Brian G. Thomas
AISTech 2012, (Atlanta, GA, May 7-9, 2012), 2012.

Transient Turbulent Flow Simulation with Water Model Validation and Application to Slide Gate Dithering
Liu, Rui, Brian G. Thomas, Bruce Forman and Hongbin Yin
AISTech 2012, (Atlanta, GA, May 7-9, 2012), 2012.

Thermal Stress Cracking of Sliding Gate Plates
Lee, Hyoung-Jun, Seong-Mook Cho, Seon-Hyo Kim, Brian G. Thomas, Sang-Woo Han, Tae-In Chung, Joo Choi
AISTech 2012, (Atlanta, GA, May 7-9, 2012), 2012.

Effect of Nozzle Clogging on Surface Flow and Vortex Formation in the Continuous Casting Mold (reprint)
Cho, S.-M., S.H. Kim, R. Chaudhary, B.G. Thomas, H.-J. Shin, W.-R. Choi and S.-K. Kim
Iron and Steel Technology, 9: 7, pp. 85-95, 2012. (reprinted from AISTech 2011, Indianapolis, IN, May 2-5, 2011, Assoc. Iron Steel Technology, Warrendale, PA).

2012 CCC Reports – Transient Mold Flow

Effect of Electromagnetic Ruler Braking (EMBr) on Transient Turbulent Flow in Continuous Slab Casting using Large Eddy Simulations (reprint)
Chaudhary, R., B.G. Thomas, and S.P. Vanka
Metallurgical and Materials Transactions B, 2012, in press.
DOI: 10.1007/s11663-012-9634-6.

Simulation of Transient Fluid Flow in Mold Region during Steel Continuous Casting (reprint)
Liu, R., B G Thomas, and J Sengupta
Modeling of Casting, Welding, and Advanced Solidification Processes (MCWASP) XIII, (Styria, Austria, June 17-22, 2012), 2012.

Transport and Entrapment of Particles in Steel Continuous Casting
Thomas, B.G., Quan Yuan, Sana Mahmood, Rui Liu, and Rajneesh Chaudhary
2012, CCC Report, No. 201202. (detailed version)

Transport and Entrapment of Particles in Steel Continuous Casting
Thomas, B.G., Quan Yuan, Rui Liu, Sana Mahmood, and Rajneesh Chaudhary
in *CFD Modeling and Simulation in Materials*, L. Nastac, L. Zhang, B. G. Thomas, A. Sabau, N. El-Kaddah, A. C. Powell and H. Combeau, eds., Orlando, FL, Mar. 12-15, 2012, TMS, 2012, pp. 279-286. (summary version of CCC Report 201202)

2012 CCC Reports – Other Mold Phenomena

Thermal-Mechanical Model Calibration with Breakout Shell Measurements in Continuous Steel Slab Casting
Iwasaki, Junya, and B.G. Thomas
in *Supplemental Proceedings: Volume 2: Materials Properties, Characterization, and Modeling, TMS Annual Meeting, Defects and Properties of Cast Metals Symposium* Orlando, FL, Mar. 12-15, 2012, 2012, pp. 355-362.

Kinetic Study of the Devitrification of Mold Powder Slags
Maldonado, Yadira G., F. Andrés Acosta, A. Humberto Castillejos and Brian G. Thomas
AISTech 2012, (Atlanta, GA, May 7-9, 2012), 2012.

Calibration of Thermal Models of Continuous Casting of Steel
Hibbeler, Lance C., Melody M. Langeneckert, Junya Iwasaki, Inwho Hwang, Ron J. O'Malley, Brian G. Thomas
AISTech 2012, (Atlanta, GA, May 7-9, 2012), 2012.

The Thermal Distortion of a Funnel Mold (reprint)
Hibbeler, Lance C., Brian G. Thomas, Ronald C. Schimmel and Gert Abbel
Metal. Mater. Trans. B., in press, 2012.
DOI: 10.1007/s11663-012-9696-5.

2012 CCC Reports – Spray Cooling

Measuring heat transfer during spray cooling using controlled induction heating experiments and computational models
Zhou, Xiaoxu, Brian G. Thomas, C. Alberto Hernández B., A. Humberto Castillejos E. and F. Andrés Acosta G.
CCC Report 201203.

Measurement of heat flux in dense air-mist cooling: Part I – A novel steady-state technique (reprint)
Hernández-Bocanegra, Constantin A., A. Humberto Castillejos E., Francisco A. Acosta-González, Xiaoxu Zhou and Brian G. Thomas
Experimental Thermal and Fluid Science, 2012, in press.
DOI: 10.1016/j.expthermflusci.2012.06.015

Measurement of heat flux in dense air-mist cooling: Part II – The influence of mist characteristics on steady-state heat transfer (reprint)
Hernández-Bocanegra, Constantin A., Jesús I. Minchaca-Mojica, A. Humberto Castillejos E., Francisco A. Acosta-González, Xiaoxu Zhou and Brian G. Thomas
Experimental Thermal and Fluid Science, 2012.
DOI: 10.1016/j.expthermflusci.2012.06.007.

2012 CCC Reports – Precipitates & Control

Multiphase Particle-Size-Grouping Model of Precipitation and its Application to Thermal Processing of Microalloyed Steel
Xu, Kun
MechSE, University of Illinois, 2012, PhD Thesis, 216p, CCC Report No. 201201.

Particle-Size-Grouping Model of Precipitation Kinetics in Microalloyed Steels
Xu, Kun and Brian G. Thomas
Metallurgical and Materials Trans. A, 43A: 3, pp. 1079-1096, 2012,
DOI: 10.1007/s11661-011-0938-y.

Robust Rejection of Sinusoids in Stable Nonlinearly Perturbed Unmodelled Linear Systems: Theory and Application to Servo
Natarajan, Vivek and Joseph Bentsman
2011 American Control Conference, (San Francisco, CA, USA, June 29 - July 01, 2011), 2011, pp. 3289-3294.

Enthalpy-based feedback control algorithms for the Stefan problem
Petrus, Bryan, Joseph Bentsman and Brian G. Thomas
51st IEEE Conference on Decision and Control, (Maui, Hawaii, Dec. 10-13, 2012), 2012.