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The Gleeble® NEWSLETTER

Fall 1997

THERMEC '97 Proves Huge Success

THERMEC '97, International Conference on Thermomechanical Processing of Steels & Other Materials, was held July 7–11, 1997, at the University of Wollongong, Australia.

More than 400 participants from 41 countries attended the conference, which focused on recent advances in the overall field of science and technology of thermomechanical process (TMP) of steels, including stainless steels and other non-ferrous materials.

Special sessions were devoted to both fundamental investigation and factory-floor issues related to casting of sheet, strip, and slabs, as well as near-net shape casting, including implementation of research finding to solve production problems. Such topics as superplastic deformation/forming, diffusion bonding, and advanced superconductors and HTSC materials were also covered at THERMEC '97.

Among the highlights of THERMEC '97 were the following keynote lectures:

- An Internal State Variable Approach to Modeling Microstructural Evolution during TMP
- Dynamic Recrystallization in Strip Mills—Industrial Fact or Metallurgical Fiction?
- Metallurgical Framework of Direct Quenching of Steel
- TMP: The Beneficial Utilization of Metallurgical Pinning Forces
- Metadynamic Recrystallization

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Gleeble Application Profiles:

Advancing the Science and Technology of Welding at Oak Ridge National Laboratory

Many people think of welding as one step away from the blacksmith's shop—a kind of fundamental joining technology that almost anyone can perform, but Dr. Stan David, Corporate Fellow at Oak Ridge National Laboratory, is out to change that.

"Welding is a key to a number of technologies—such as energy, construction, aerospace, automotive, and shipbuilding—that comprise a significant fraction of the national economy," Dr. David says. "We need to understand it better, including the relationships between process, microstructure, and properties, so that we can create welded joints of the highest integrity and improve productivity."

He adds, "In all applications, despite its apparent simplicity, welding is a complex process that requires a multi-disciplinary approach to truly understand. It is, at its heart, an engineered science, and we need

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Dr. Stan David (right) and Robert Reed, a technologist, prepare for a test on the Gleeble at Oak Ridge National Laboratory.

Recent Gleeble Papers

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Evaluation of HAZ Hot Cracking Susceptibility of 347 Nuclear Grade Stainless Steels

by C. D. Lundin and C.Y.P Qiao

HAZ hot cracking susceptibility of 347 nuclear grade stainless steels was addressed by hot ductility and varestraint techniques. Nitrogen showed a beneficial influence on the base metal HAZ of hot cracking resistance. Control of N, Nb, and C as well as the Cr/Ni ratio is important in developing the optimum in weldability. Hot ductility testing criteria, namely, ratio of ductility recovery (RDR), ductility recovery rate (DRR), nil ductility temperature range (NDR), and the varestraint hot crack evaluation criterion of cracked heat affected zone length (CHL) have been demonstrated. Good correlations between hot ductility testing and Varestraint testing have been obtained and this indicates that the methods can be used in complementary fashion.

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The Effect of Niobium on the Hardenability of Microalloyed Austenite

by C. Fossaert, G. Rees, T. Maurickx, and H.K.D.H. Bhadeshia

The powerful effect that varying the extent of niobium-carbide dissolution has on the “hardenability” of microalloyed austenite is demonstrated using dilatometric measurement of the critical cooling rate required to form microstructures containing >95% martensite. The results can be rationalized on the hypothesis that the hardenability of austenite is enhanced by niobium in solid solution, possibly by its segregation to austenite grain boundaries, but is decreased by precipitation of niobium-carbide particles. This effect appears analogous to that of boron in steels and is found to be independent of variations in the austenite grain size.

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Simulating the Formation of Hot-Rolled Structures in 1100 Aluminum Alloy Using a Gleeble Test Machine

by Yoji Hirano and Takeyoshi Doko

A Gleeble test machine was used to simulate plane strain deformation in investigating structural changes in 1100 Al alloy during the hot rolling process. In preliminary experiments, the temperature distribution in alloy specimens was found to be uniform when they were heated by direct current flow. Stratified specimens composed of 1000 and 2000 alloy were compressed to investigate the strain distribution, and it was confirmed that rolling equivalent to the amount of strain applied was carried out at specific locations. Then a single-pass compression test was carried out at 400°C and the subgrain formation behavior during hot deforming investigated. As the amount of strain increased the subgrain bounders became clearer, with subgrains forming at a strain of approximately 0.36. In addition, the higher the strain rate the smaller the diameter of the subgrains, the clearer the grain boundaries became and the smaller the dislocation in the subgrains.

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Interfacial Layer Development in Hot-Dip Galvanneal Coatings on Interstitial Free (IF) Steel

by C.E. Jordan, K.M. Goggins, and A.R. Marder

During the annealing of hot-dip galvanized coatings on interstitial free (IF) steel, an interfacial layer was found to develop and grow at the steel/coating interface. The interfacial layer followed a three-step growth process in which there was initial rapid growth up to a thickness of approximately 1.0 µm, followed by a period of essentially no growth with continued zinc and iron interdiffusion into the coating, and finally renewed growth at long time (60 second) anneals. The interfacial layer did not inhibit zinc and iron interdiffusion or the development of the Fe-Zn alloy layer. Coating iron content increased rapidly before the interfacial layer grew to a thickness of 1.0 µm, however, once the coating reached a total iron content in excess of 11.0 wt%, interfacial layer became active and coating iron content increased only slightly with continued annealing. Although powdering of the coating as evaluated by a 60° bend test was generally found to increase with an increase in interfacial layer thickness, particularly in excess of 1.0 µm, no definitive relationship between interfacial layer thickness and powdering was found. The thickness of this interfacial layer, however, can be used as an indicator of formality performance.

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Kinetics and Formability of Hot-Dip Galvanneal Coatings

by C.E. Jordan, K.M. Goggins, and A.R. Marder

Process modeling was performed on the Gleeble HAZ 1000 to evaluate the morphology and formability properties of hot-dip galvanneal. Using the Gleeble to control coating morphology, and light absorption to quantitatively measure the degree of powdering, a relationship between coating morphology and optimum formability was determined. Hot-dip galvanized coatings are annealed to improve coating weldability and paintability for subsequent use in automobile manufacture. The FeZn alloyed coating, galvanneal, contains approximately 10 wt% iron. The FeZn phases that develop within the coating can result in poor formability properties and powdering of the coating upon stamping of the coated sheet steel. To improve the understanding of galvanneal structure and property relationships, the research presented here has focused on simulating hot-dip galvanneal microstructure and evaluating coating powdering behavior after 60° bend testing.

Welding Technology at Oak Ridge National Laboratory

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powerful research tools for getting a handle on it."

Oak Ridge National Laboratory has been using a Gleeble 1500 for about ten years to simulate HAZ microstructures, understand phase transformations, and test the weldability of metals and alloys.

"We really have two basic directions of research here involving the Gleeble: one is very basic, very fundamental; the other very 'applied.' The basic research is aimed at establishing the science base for this important technology." The research is sponsored by the Division of Materials Sciences, Basic Energy Science, U.S. Department of Energy.

One of the things that Dr. David and the Materials Joining Group at Oak Ridge National Laboratory are looking at is transport phenomena. They want to know what's happening in the weld pool. They're looking at inclusion formation in steel welds, trying to establish the fundamentals for how the inclusions form, what kind they are, and what the distribution is.

Recently, in an experiment that took a year to design, the Oak Ridge researchers used the Gleeble to simulate approximately fluid flow in a weld pool. "The heat source interacts with the material and produces a liquid pool," Dr. David says. "Inclusions are coming out. A lot of motion is taking place within the weld pool, and as inclusions form, particles are moving around and colliding with each other. So we wanted to know: what happens then?"

"We physically simulated the potential situation that can occur in a weld pool and found that two particles can collide and coalesce. That's something new we hadn't understood before," he adds.

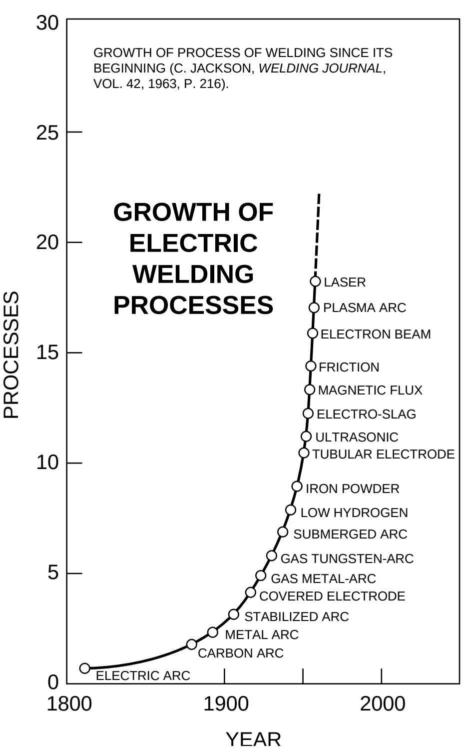
Another effort has been aimed at understanding "soft zone" formation during the welding of chrome-moly steels. "We knew that welding produced a weak zone, but how and why? If you simply make a weld, the soft zone is so small that it is impossible to sample and test it."

With the Gleeble, they simulated the gradients and microstructures that one can get in the heat affected zone of chrome-moly steels. Using high resolution electron microscopy and a microhardness indentation tool, they were able to characterize and understand what is going on in the soft zone. Through Gleeble simulation, they were able to widen the soft zone so that it could be sampled, tested, and analyzed.

The team at Oak Ridge is also using the Gleeble to characterize the weldability of nickel-based superalloys, steels, aluminum alloys, and a number of intermetallic alloys, by measuring nil-strength and nil-ductility temperatures. With the help of computational thermodynamics, they are determining the effect of various major and minor elements on weldability.

Another area under scrutiny at Oak Ridge National Laboratory is the effect of residual stress on solid state transformation. "When you make a weld, thermal stresses are generated in the material. How do they influence the solid state transformation in various alloys?" They use the Gleeble to heat and transform alloys, apply stress and determine its effect on transformation characteristics.

A steady stream of papers issued from Oak Ridge National Laboratory's Materials Joining Group indicates that Dr. David and his colleagues are making significant progress in their effort to improve both the fundamental understanding and practical application of welding.



Come See Us at the Shows!

Fifth International Conference on Trends in Welding Research, June 1–5, 1998, Pine Mountain, Georgia

Visit us at the Fifth International Conference on Trends in Welding Research to be held June 1–5, 1998, in Pine Mountain, Georgia. DSI Applications Engineers will be available to discuss welding simulations and applications on Gleeble Series 3 systems.

For more information about this meeting, contact:

American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126
Tel (U.S.): (800) 443-9353, ext. 223
(International): (325) 443-9553, ext. 223
Fax: (305) 443-1552

AEROMAT '98, June 15–18, 1998, Washington D.C.

DSI will be exhibiting the latest in Gleeble Systems technology at Booth #7 at AEROMAT '98, to be held at the Sheraton Premiere at Tysons Corner, Washington D.C.

For additional information, contact:

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THERMEC '97 Proves Huge Success

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- Microstructure Development by Thermomechanical Processing in Duplex Stainless Steel and Beta-Ti Alloy
- Thermomechanical Processing of High Strength and Mild Flat-Rolled Steels
- The Recrystallization of Particle-Containing Aluminum Alloys
- Al-Alloys and the Thermal Processing Associated with Automotive Sheet

Over 330 papers were presented. THERMEC '97 proceedings will be published by TMS–USA and are expected to be ready by the time you read this. The proceedings can be ordered from:

TMS
420 Commonwealth Dr.
Warrendale, PA 15086 USA
Tel: (412) 776-9050
Fax: (412) 776-3770
Internet: www.tms.org

The cost will be around $160–170 (U.S.) for two volumes.

Australian University Selects Gleeble 3500 for Advanced Materials Studies

A Gleeble 3500 system has been delivered and installed at the University of Wollongong in Wollongong, Australia.

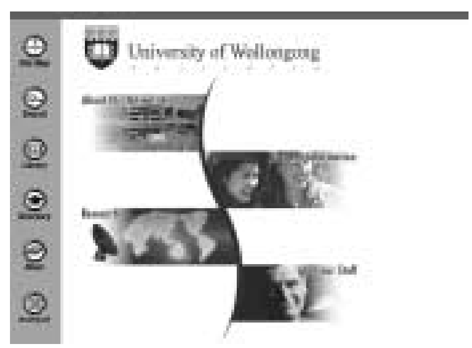
The Gleeble 3500 at the University of Wollongong will be used by four major research groups:

- The Cooperative Research Centre in Materials Welding and Joining,
- The Australian Nuclear Science and Technology Organisation,
- The BHP Institute for Steel Processing and Products, and
- the Research Centre for Advanced Materials Processing.

Projects include a wide range of welding simulations, simulations of rolling and forging ferrous and non-ferrous materials, and deformation studies of semi-solid metals.

The Gleeble 3500 is capable of heating specimens at 10,000°C/second and applying loads as high as 10 tons of force. All Gleeble 3500 systems feature the DSI Series 3 Digital Control and incorporate closed-loop thermal and mechanical systems. Windows® based QuikSim, a spreadsheet-like, fill-in-the-blanks software program, provides quick and easy programming of the Gleeble. Test results are automatically fed to Origin®, an industry standard, data analysis software package. Origin features templates such as stress vs. strain, force vs. time, temperature vs. time, etc. Once information has been loaded, plots are generated in a matter of moments by simply clicking on the desired template.

Gleeble systems are used for process simulation, materials characterization, and basic research in technical institutes, industrial laboratories, and universities throughout the world. For additional information, contact DSI or visit the DSI Web site at www.gleeble.com.



The University of Wollongong Web site can be found at http://www.uow.edu.au/.

Gleeble Newsletter

The Gleeble Newsletter is intended to be a forum for Gleeble users worldwide to exchange ideas and information. We welcome your comments and suggestions. Letters, comments, and articles for the newsletter may be addressed to David Ferguson at Dynamic Systems Inc., faxed to us at (518) 283-1360, or e-mailed via the Internet: info@gleeble.com.