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# The Gleeble®

## NEWSLETTER

Spring 2006

### See Us at the Shows

**THERMEC' 2006, July 4-8, 2006, Vancouver, Canada**

THERMEC' 2006, International Conference on processing and manufacturing of advanced materials will be held July 4-8, 2006, at the Fairmont Hotel, Vancouver, British Columbia. The Conference will cover all aspects of processing, fabrication, structure/property evaluation and applications of both ferrous and non-ferrous materials including hydrogen and fuel cell technologies, metallic glasses, thin films, ecomaterials, nanocrystalline materials, biomaterials and other advanced materials.

For further information, visit <http://thermec.uow.edu.au> or contact:

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**Advances in Materials and Processing Technologies (AMPT), July 30-August 3, Las Vegas**

AMPT will be held July 30 to August 3, 2006 at the Flamingo Hotel in Las Vegas, Nevada. The conference provides a forum both for senior as well as young scientists and academics around the world who are actively involved with research in the fields of Materials Science and Materials Processing to come together and share their experience of any advances they have made in those areas.

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### Gleeble Application Story

## The Gleeble at The University of British Columbia

At the University of British Columbia, a Gleeble 3500 is helping to pave the road for the future in materials processing in a variety of ways.

At the Centre for Metallurgical Process Engineering, the Gleeble is, for nearly two decades (initially with a Gleeble 1500), an essential educational and research

tool used by undergraduates, Masters and PhD candidates, and post-doctoral students. Dr. Warren Poole, Professor in the Department of Materials Engineering, says, "Almost all of our work with students involves research projects for industry. Some of these projects also have

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## RPI Students Visit DSI

Recently a group of Materials Engineering and Mechanical Engineering students from Rensselaer Polytechnic Institute visited DSI. The students, who are taking a Welding Engineering Course

taught by Prof. Robert W. Messler of the Materials Science and Engineering Dept., came to see first hand how the Gleeble 3500 and Gleeble 3800 are used to trou-

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RPI professor Robert Messler's welding engineering class visited DSI recently.

# Recent Gleeble Papers

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## Study of the Microstructures and Properties of Simulated Heat Affected Zone in Laser Welding of ULCB 600 Steel

by Q.F. Wang, J.H. Liu, Z.Y. Li, P.H. Li, G.F. Zhou, and X. Chen

The microstructure and properties of simulated heat affected zone (HAZ) of laser welded ULCB 600 steel were investigated by applying the simulation technique with a Gleeble 2000 dynamic thermal-mechanical simulator. The influence of the preheat condition on the microstructure and properties of simulated HAZ of laser welded plate was also studied in order to evaluate the feasibility of reducing a risk that the ductility and toughness of HAZ may be poor by using preheat treatment. The results indicated that the grain size of laser-welded HAZ simulated is very small no matter if there is preheat; the toughness of simulated HAZ is therefore improved, compared to the base metal, and there is no obvious brittle-ductile transition in the range from  $-80^{\circ}\text{C}$  to  $20^{\circ}\text{C}$ . The TEM analyses of submicrostructure also discovered that microstructure constituent of both simulated HAZ is dominative lath martensite. However, the sheaf of martensite is relatively coarse, and the dislocation density is relatively high for simulated HAZ with  $200^{\circ}\text{C}$  preheat because of slower cooling rate. Combination of these two factors is responsible for lower hardness and better toughness of simulated HAZ with preheat condition.

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## A Comparison of Published HAZ Thermal Simulation Methods Used to Derive Weld HAZ Thermal Cycles

by C.D. Lundin and G. Zhou

Accurate thermal simulation is the key in the simulation approach to defining the unique microstructure and properties of weld HAZ regions. Simulation enables an expansion of the volume of material characteristic of each HAZ region to a

sufficient size for property determination. The combined influence of heat input, preheat temperature, plate thickness, and welding process on HAZ microstructure and properties relies on the accurate simulation of thermal cycles corresponding to different peak temperatures using an HAZ simulator like the Gleeble. Several computer programs have been developed to predict thermal excursions in various HAZ regions during welding. Some were developed based simply on the thermal properties of the material; whereas, others were generated on the basis of actual experimental data. A suitable HAZ thermal simulation program must be one that can authentically duplicate an actual thermal cycle experienced during welding within reasonable limits. Therefore, the similarities and differences among the HAZ thermal cycles predicted by various methodologies should be fully understood. A total of six thermal cycle prediction methodologies were compared in this evaluation. It was determined that some HAZ simulation programs have severe limitation due to the idealized assumptions considered in their development. According to the experience at The University of Tennessee and the comparison results in this study, the HAZ thermal simulation programs; "HAZ Calculator" and  $F(s, d)$ ; are recommended for accurate HAZ thermal cycle duplication.

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## HAZ Cracking and Hot Ductility of $\text{Ni}_3\text{Al}$ Containing Zr Alloy

by B.N. Qian, J.L. Li, J.T. Guo, and B.Z. Wei

The HAZ cracking test in EB welding condition and the hot ductility test show that the cracking mechanism is the formation of Ni-Ni<sub>3</sub>Zr eutectic which is resulting from the enrichment of Zr in grain boundaries during welding. In order to eliminate HAZ cracks the diffusion and recrystallization annealing treatment after cast and during cold rolling should be conducted in vacuum or protecting atmosphere and at the same time a slow welding speed is necessary.

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## Resistance Brazing of SiC/2024Al Composite

by L.H. Han, Q.C. Meng, J. Zhang, and J.T. Niu

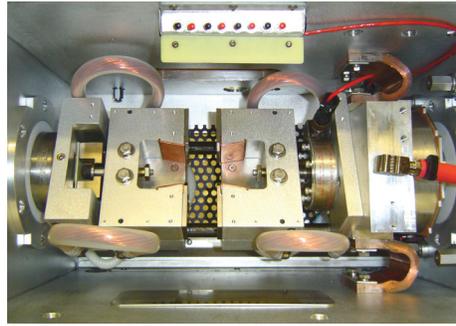
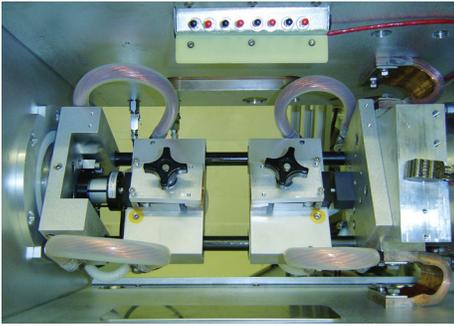
The resistance brazing of 2024Al reinforced with 15 volume percent of SiC<sub>p</sub> particulate was simulated by using a Gleeble 1500 thermal/mechanical simulator. The results show that too high or too low brazing temperature and pressure result in decrease in shear strength of joint, but brazing time influences it slightly. The action between filler metals and the composite was analyzed by SEM and EPMA. The use of simulation method helped in the design and prediction of welding technology, which reduced the rejection rate as well as the cost of production.

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## Stress Relaxation Study of HAZ Reheat Cracking in Type 347 Stainless Steel

by L. Li and R.W. Messler, Jr.

Four different compositions of Type 347 austenitic stainless steel were studied using Gleeble-based stress relaxation tests to evaluate susceptibility to weld HAZ reheat cracking. Coupons extracted from plate were thermally cycled to reproduce the coarse-grained region of the HAZ known to be most prone to such cracking. These samples were then reheated to various PWHT temperatures, and a strain comparable to 70% of the strain to cause yielding at the temperature was applied. Force in the specimens was recorded for up to 3 h while this total strain was kept constant. Force vs. time curves for all samples exhibited an increase attributed to volumetric shrinkage upon precipitation of Nb-rich particles as confirmed by constant-stress tests. Formation of Nb-rich precipitates strengthens the alloy, and stress buildup due to volumetric shrinkage in the age-hardening matrix leads to cracking along grain boundaries when stress cannot relax fast enough by yielding or creep.



The Gleeble is configured for nil-strength temperature (left) and with low force pocket jaws (right).

## Gleeble System NST and Low Force Jaws

The possibility of cracking during rolling, casting, continuous casting, and welding processes is greatly reduced if the range between the material's Nil-Strength Temperature and Nil Ductility Temperature is smaller than 20°C. Standard thermal/mechanical testing machines, however, are often unable to control, apply and measure the very small tensile force required for Nil Strength Temperature (NST) testing.

The Gleeble System NST and Low Force Jaws, available for most Gleeble Systems, create the conditions necessary for achieving accurate, reproducible NST, NDT, DRT and similar values, and measuring low forces in tension or compression. The jaws are also useful for unrestrained thermal testing, such as CCT and TTT, as they reduce the machine induced mechanical effects of thermal expansion on the specimen.

The 9500 series jaw set is designed for maximum flexibility and versatility depending upon application. This creates a wide variety of choices and can be user-configured in many different ways, depending upon your testing needs.

The Nil-Strength Jaw Set is appropriate if your application includes any of the following:

- Standard Nil-Strength test
- Tensile test with maximum force less than 50 lb. and a specimen size of 6 mm or 1/4"

- Tensile testing of flat sheet up to 1 mm thick and 15 mm wide with a peak force of less than 50 lb.
- Maximum heating rate of 30°C/second or less (steel specimens)

The Nil-Strength Jaw Set includes the grip mounting assembly and a pneumatic cylinder for applying low force loads (less than 50 lb.) to the specimen during the test. The pneumatic cylinder provides the tensile force instead of the much larger hydraulic system thus allowing very fine control of small loads. The air cylinder has a full travel distance of 25 mm (1.0 inch). This grip setup is for constant force testing only. An optional load cell can be used to provide precise measurements of the actual load applied to the specimen during the test.

If your application includes hot tensile testing using small specimens or low forces, the Low Force Pocket Jaw Assembly can be used. Applications for the Low Force Pocket Jaw Assembly include dilatometry studies and mushy zone work.

For information on how to configure NST and Low Force Jaws to meet your testing needs, request our application sheet, "Nil-Strength, Low Force Tensile and Compression Testing." Write Dynamic Systems Inc., P.O. Box 1234, Route 355, Poestenkill, NY 12140 USA; telephone 518 283-5350; fax 518 283-3160, or email [info@gleeble.com](mailto:info@gleeble.com).

## RPI Students Visit DSI

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bleshoot welding problems and simulate welding processes through physical simulation. Welding studies include thermal cycling to produce microstructures for metallographic studies, dilatometry to determine critical transformation tempera-

tures on heating and cooling, nil-strength testing, post weld heat treatment, constitutional liquation, and more. During their visit they also learned how steel makers use Gleeble systems to study rolling, forging, strip annealing, and other steel processes.

## See Us at the Shows

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The conference scope includes: materials, sheet forming, bulk forming, powder forming, forming the melt or near-melt condition, material-removal processes, surface engineering, nano technology, computer applications, and environmental issues.

For more information about the conference, visit <http://www.ohiou.edu/ampt/index.html>

Conference Organizers invite papers from researchers and practitioners from academia as well as industry within the scope of the conference subjects. Sessions will be developed according to the level of interest for each Conference Topic.

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## Don't Forget: Gleeble Newsletter Going "All Electronic"

Starting with the Winter 2007 edition, the *Gleeble Newsletter* is going all electronic. Instead of a printed newsletter, it will be delivered via email as a PDF file.

It will still contain the same type of editorial content that you have come to expect from the *Gleeble Newsletter*, but it will come to you via the Internet. As a result, depending on your location, you will receive the electronic version up to two weeks sooner than the paper version delivered through postal mail.

To make sure you receive every single issue of the *Gleeble Newsletter*, sign up for the electronic edition today. It's easy. Just email [info@gleeble.com](mailto:info@gleeble.com) and tell us you want to receive the electronic version of the Gleeble Newsletter, or sign up on our website, [www.gleeble.com](http://www.gleeble.com).



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## *The Gleeble at The University of British Columbia*

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funding from Canada's Natural Science Engineering Research Council (NSERC)."

He adds, "For example, some of our fourth year students have been studying in their team-based project courses heat affected zones and continuous cooling transformation for a company that makes pipeline steel. Their work will help the company to make steel that will be better suited for surviving in extreme environments."

One of the research projects conducted by the team at the Centre for Metallurgical Process Engineering was a very large undertaking supported by the American Iron and Steel Institute and also funded by the US Department of Energy. The project was aimed at developing a computer model for the hot rolling of steels which was led by a remarkable team of professors including the late J.K. Brimacombe, I.V. Samarasekera, T.R. Meadowcroft, E.B. Hawbolt, M. Militzer and W. Poole. Initially, eight low-carbon steels were included.

"We had to generate all the parameters and then to validate the predictions that the computer model made," Dr. Poole says. "The Gleeble played a central role in that project. We did austenite grain growth studies, double-hit compression tests to study recrystallization, and continuous cooling transformations, with and without compression."

The project was a success, and now a commercial software program for the modeling of hot steel rolling is available.

Using the software, steel companies can set the processing parameters for their rolling mills to produce steels with the characteristics they want. Drs. Militzer and Poole are continuing to work with Dofasco, Canada's largest steel manufacturer, to add additional steels to the model, including dual phase and TRIP steels.

Another project, funded by a strategic grant from NSERC, required using the Gleeble to study the annealing of cold-rolled sheet metals, including steels and aluminum alloys. "These investigations mostly involved taking advantage of the Gleeble to control the heating rate, to study the softening, recovery and recrystallization of the materials," Dr. Poole says.

This study, which was done in collaboration with Alcan, Dofasco, and Stelco—Canada's largest suppliers to the automotive industry—aimed at developing a computer model that would allow the companies to see how changing processing conditions in their plant would affect the final product. "The ultimate goal," Dr. Poole says, "is to help the companies produce lighter, stronger materials for automobiles and SUVs that are safe, offer excellent performance, yet require less fuel to move them."

He adds, "Automotive companies would like to custom-tailor materials for their use: for example, high-strength materials in bumpers and side-impact beams, and highly formable materials for fenders and door panels."

Using the Gleeble's strip annealing



*Dr. Warren Poole prepares a low-force test on the Gleeble 3500.*

setup, the team at UBC generated data and validated results for a software process model that the materials companies are now using. With it, they are able to reduce the number of trial iterations needed to produce materials with the characteristics they want.

In related work, one of Dr. Poole's colleagues, Mary Wells, has been working on the hot deformation of magnesium alloys in a controlled atmosphere. She has also been doing a number of tests on the hot cracking of aluminum alloys in the semi-solid state.

"Our forte is the development of process models," Dr. Poole says. "The Gleeble provides a cost effective way to physically simulate high-temperature processes and applications at a far lower cost than full-scale tests. You would need at least two or three other machines to duplicate what we do here, where one Gleeble can do it all."