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The Gleeble® NEWSLETTER

Spring 1999

Come See Us at the Shows

AeroMat '99, Dayton, Ohio, June 21–24, 1999

Come talk to DSI's applications engineers about your materials characterization and physical simulation needs at Booth 13 at the Dayton Convention Center.

Materials Solutions Exposition & Conference, Cincinnati, Ohio, November 2–4, 1999

DSI will be exhibiting the latest in Gleeble Systems technology at Booth 801 at the Cincinnati Convention Center. Stop by to see what's new.

For additional information about either show, contact:

ASM International
9838 Kinsman Rd.
Materials Park, OH 44073 USA
Tel: (440) 338-5151
Fax: (440) 338-4634
Internet: www.asm-intl.org

Gleeble Application Profiles:

Gleeble Simulation Studies at MTL-CANMET—the 1990s

by James Gianetto, John Bowker, Don Baragar, Elhachmi Essadiqi, and Murray Letts, MTL-CANMET

The Materials Technology Laboratory (MTL)-CANMET is located in Ottawa, Ontario, Canada and is a division within the Minerals and Metals Sector of the Department of Natural Resources Canada.

The Gleeble 2000, a thermal-mechanical simulator, has featured prominently at MTL-CANMET as a key research tool in projects addressing a broad range of materials issues. In several projects, staff have evaluated structures and properties of weld metal and heat-affected-zone (HAZ) regions in high-strength steels for marine ships, offshore structures and pipelines. Under others, we have investigated heat resistant alloy steel, Ni-Al bronze, Al metal matrix composites and Ti alloys. More recently, work has focused on simulating various steelmaking processes, including continuous casting, strip annealing and high temperature properties, such as hot ductility.

Investigations with the Gleeble simulator in welding simulation have included evaluation of microstructure and toughness of heat-affected zone (HAZ) regions in C-Mn, low alloy, and high strength steels, focusing on the influence of steel composition, energy input and reheating over a wide range of conditions. Other areas of interest include characterization of transformation behaviour of high-strength steel weld metal and HAZ regions using dilatometry to generate continuous cooling transformation diagrams, simulation of weld metal and HAZ regions in laser weld cladding of Ni-Al bronze (NAB), and pressure welding of Al metal matrix composites and Ti alloys.

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Murray Letts, MTL-CANMET Senior Technologist, sets up a continuous casting experiment.

DSI Announces Hot Torsion System

A revolutionary system for performing hot torsion tests on metallurgical samples is now available from DSI.

The Gleeble 35050 Hot Torsion Mobile Conversion Unit (MCU) incorporates a number of new and innovative designs in the field of metallurgical hot torsion testing. Both Gleeble 3500 and 3800 systems are designed to accept a variety of Mobile Conversion Units. Each MCU allows the Gleeble system to perform specialized testing in an optimal fashion. The 35050 Hot Torsion MCU is the most recent in a series of Mobile Conversion Units which includes the Hydrawedge MCU for high-speed hot deformation simulation.

Capable of applying torque at up to 100 Nm, the 35050 Hot Torsion Mobile Conversion Unit is the first commercially available torsion testing system to incorporate a direct resistance heating system. This provides the capability to allow:

- rapid, uniform heating of samples,
- fast, readily repeatable testing of multiple samples,
- heating of test specimens at any time during torsion, and

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Recent Gleeble Papers

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Effect of Heat Input on the Microstructure and Mechanical Properties of the Heat-Affected Zone of Duplex Steel

by R.A.M. De Schrevel, F. Ijsseling, D. Helder, V.J. Gadgil, Hengelo, and B. H. Kolster

Simulations of the heat-affected zone were carried out on austenitic-ferritic duplex stainless steel. The microstructural changes were studied. The effect of heat input on the phase content and on impact properties was investigated. The results show that high heat input is favorable to the mechanical properties. The elements partitioning in the two phases were studied. Macro- and microhardness profiles show a peak in the heat-affected zone. Austenite is found to be harder than ferrite in the heat-affected zone.

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Weldability of an Abrasion-Resistant Steel

by Y. Adonyi, W.F. Domis, and C.C. Chen

The welding performance of a low-carbon-equivalent, abrasion-resistant steel newly developed for the mining industry was studied using a combination of simulative and actual weldability tests. The susceptibility to hydrogen-induced cracking in the weld-metal and heat-affected zones (HAZ), as well as the potential loss of strength and toughness in the HAZ, were evaluated. Simulative testing included the use of the Gleeble 1500 thermomechanical simulator to produce single- and multiple-pass weld HAZ microstructures on CVN-size specimens. The effects of heat input, interpass temperature, and post-weld heat treatment (PWHT) on the HAZ microstructure and properties were determined. Additionally, a computer software was used to predict theoretical HAZ hardness and volume fraction of phases as a function of cooling rates. The actual welding tests included the Gapped Bead-on-Plate and the Y-groove tests to determine the weld-metal and HAZ susceptibility to hydrogen-induced cracking. Three heat inputs, two diffusible hydrogen and two weld-metal yield-strength levels were used for the actual welding stage. Good correlation was found between microstructure predictions, physical simulations, and actual weld testing results. The new steel was found to be highly weldable because of the low preheat required to avoid HAZ hydrogen induced cracking. All aspects of weld-metal and HAZ cracking behavior had to be addressed for a complete weldability characterization. It was also found that use of excessive heat inputs and PWHT should be avoided when welding this type of steels.

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Cleavage Initiation in Ti Microalloyed Steels

by D.P. Fairchild, D.G. Howden, and W.A.T. Clark

The toughness of two microalloyed, thermomechanical control process steels were investigated (steels A and B). Steel A was microalloyed with 0.076V, 0.028Nb, and 0.011Ti, while steel B contained 0.048Ti. Coarse grain heat affected zone (CGHAZ) specimens were produced by Gleeble simulation. Toughness was measured using instrumented precracked Charpy, Charpy-V-notch, and double crack, 4-point bend tests. Optical and scanning electron microscopy were used for microstructural and fractographic analysis. In all cases, steel A showed better cleavage resistance than steel B. SEM fractography revealed no distinct features at the initiation sites of steel A. At the initiation sites of steel B, however, TiN inclusions were consistently found; their existence verified by EDS. Without exception, when a TiN related initiation site was located, a piece of TiN was found in each mating fracture surface. Evidence of matching river patterns within the inclusion halves, frequent sidecracks within the inclusions, and the absence of microvoiding established the cleavage initiation mechanism in steel B as the fracturing of brittle TiN particles. By quantitative microscopy it was estimated that about 0.0016wt% of steel B's Ti (less than 3.5% of the total) was tied up in the TiN inclusions. This indicated that, depending on casting schedule, TiN related toughness degradation could potentially occur in steels with modest Ti content.

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Static Recrystallization in Austenitic and Ferritic Stainless Steels Investigated by the Stress Relaxation Method

by L.P. Karjalainen, J.A. Koskiniemi, and X.D. Liu

The stress relaxation method was used to investigate the effects of experimental variables on the kinetics of static recrystallization in austenitic Type 304 and ferritic 12%Cr stainless steels. The data on the 304 steel were compared with the published data as well as with the results of double-hit compression tests and a metallographic examination of the recrystallized fraction. The effect of a change in temperature during deformation on the recrystallization rate was also determined in the latter steel. A fairly good consistency between the results of the relaxation tests and those previously reported highlights the applicability of the stress relaxation technique. Double-hit compression yields considerably higher softening fractions at short times due to the influence of static recovery. The metallographic measurements indicate the sensitivity of the stress relaxation method and show that the load present during relaxation has no detectable influence on the recrystallization rate. The effects of strain, strain rate and temperature on the kinetics of recrystallization in the 12%Cr steel are close to those in the 304 steel, but the softening rate in about twofold. The findings on the effect of temperature change during deformation show that the recrystallization rate is controlled by the final temperature.

Gleeble at MTL-CANMET

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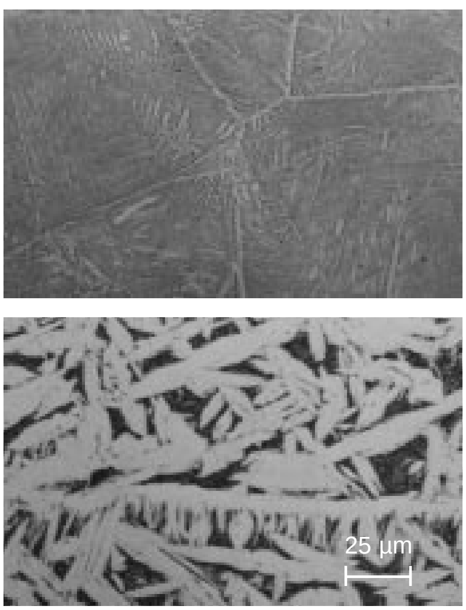
Continuous casting simulations on the Gleeble simulator have proven invaluable in assessing hot-ductility for a range of steels for integrated steel mills and mini mills and for studying austenite grain size as a function of cooling rate of the as-cast strand.

In the area of thermo-mechanical processing, the Gleeble simulator has made it possible to compare reheated and rolled and direct rolled simulated microstructures produced with accelerated cooling for thin slab cast products. We have also studied the influence of slab reheat and deformation temperatures on hot-ductility for optimization of processing schedules and established optimal forging conditions for alloy steel and intermetallic alloys. In addition, we have used it for measurement of recrystallization kinetics.

The strip annealing simulation capabilities of the simulator have aided our studies of continuous annealing conditions on recrystallization and texture of interstitial free (IF) steels. We have used it to investigate the effects of simulated interrupted galvannealing treatments on phase transformations in galvanized IF steel, including rapid annealing with very fast cooling rates.

We use the Gleeble simulator to develop new techniques, including:



Top: martensitic structure formed with Tm = 1064°C + water quench ($\Delta t_{800-500}$ = 0.4 s). *Bottom: Widmanstatten* α *structure formed with* Tm = 1064°C + air cool ($\Delta t_{800-500}$ ~ 7 s).

- simulation of weld metal regions in Ni-Al bronze, a technique that allows in-situ melting and rapid cooling by water quenching,
- development of new techniques for measuring and interpreting hot-ductility results, and
- refinement of stress-relaxation technique for determining precipitation kinetics.

Gleeble simulation plays a key role at MTL-CANMET. It allows controlled experiments and detailed characterization of samples subjected to known thermo-mechanical conditions to be carried out. These studies have given MTL-CANMET an improved understanding of the effects of critical process variables in casting and processing of steel, strip annealing and welding.

In studies to simulate the microstructure in laser clad NAB, we achieved very fast cooling times for both simulated weld metal and HAZ regions. For the simulated weld metal, we developed a technique which allowed melting and subsequent fast cooling to facilitate assessment of both as-deposited and reheated weld metal regions. Use of this technique provided insight into the phase transformations that occur during laser weld cladding.

One area that is gaining increased attention as an alternative method for steel production is thin-slab casting and direct rolling. Although economic benefits of reduced capital costs and increased energy savings can be realized, there is a need for a more fundamental understanding of the differences between microstructural development in conventional reheat rolling and the direct rolling processes. MTL-CANMET has used Gleeble simulations for microstructural evaluation and determination of the temperature at which partial recrystallization occurs. Performed in conjunction with experiments carried out using the CANMET thin-slab casting simulator and pilot-scale rolling mill, work has provided insight into the processing structure—property relationships that must be incorporated in the design of processing schedules for steel production using thin-slab casting and direct rolling.

MTL-CANMET's bottom line: the Gleeble 2000 simulator has become an essential tool in our quest to help Canadian industry with materials technology.

DSI at Conferences

DSI will participate in the following conferences with technical representatives and/or presentations.

Recrystallization '99

The fourth international conference on Recrystallization and Related Phenomena will be held at the National Research Institute for Metals (NRIM) in Tsukuba Science City, Japan, on July 13–16, 1999.

For more information contact:

ReX '99 (JIMIS-10) Secretariat
Ms. En Furutsuki, Conference Liaison
National Research Institute for Metals (NRIM)
1-2-1 Sengen,
Tsukuba 305-0047, Japan
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International Conference on Physical and Computer Simulation of Hot Working

An international conference on Physical and Numerical (Computer) Simulation of materials and hot-working will be held in Beijing, China, on October 10–14, 1999.

For additional information contact:

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16th International Forging Congress

The 16th International Forging Congress will be held September 9–16, 1999, in Beijing, China.

For more information contact:

China Forging Industry Association
5 Xisanhuan Beilu,
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Hot Torsion Mobile Conversion Unit

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- rapid quenching of the test specimen at any point in the test.

Until now, metallurgists who wanted to perform torsion tests were forced to use systems that used either furnaces or induction heating to bring a specimen to a desired temperature. Furnaces are slow and often require hours-long heating and "soaking" of samples to ensure uniform temperatures throughout the specimen. Induction heating places a coil around the specimen, interfering with direct measurements on the surface and requiring precise coil placement or reproducibility from test to test suffers.

Neither furnace nor induction heating allows immediate in-situ quenching. Both require removal of the heating apparatus before quenching can be done. Direct resistance heating allows immediate quenching of the specimen at any time during the test program without damage to the heating system.

In addition, through direct resistance heating and its unique grip design, the Gleeble 35050 Hot Torsion MCU can rapidly produce a uniform temperature (±5°C) across the entire gage length (up to 50 mm) of the specimen. This means that researchers can perform more tests, more accurately and faster than ever before.

The Gleeble 35050 Hot Torsion MCU also incorporates another innovation in the field of torsion testing: use of a variable coupler allows acceleration of the torsion motor before engaging rotation of the specimen. This means that "ramp up" to the desired rotation speed is reduced to an absolute minimum, again increasing the accuracy and repeatability of results.

In another first for a commercially available hot torsion system, this unit also incorporates the unique capability to apply controlled tension or compression at any time during the torsion test through closed-loop servo-hydraulics.

The 35050 Hot Torsion MCU incorporates a direct resistance heating system.

The Gleeble 35050 Hot Torsion MCU features the DSI Series 3 Digital Control and incorporates closed-loop thermal and mechanical systems. Windows-based computer software, combined with an array of powerful processors, provides an extremely user-friendly interface to prepare torsion test programs, to provide digital closed-loop control of the thermal and mechanical systems, and to collect data.

An application note on torsion testing is available. Contact us for a copy.

Recent Installations around the World

Dynamic Systems Inc. welcomes the following organizations as users of Gleeble physical simulation systems.

A Gleeble 3500 system has been delivered and installed at the **University of Bayreuth**, Bayreuth, Germany.

The Gleeble 3500 at the University of Bayreuth will be used to determine weldability and hot cracking susceptibility of aluminum alloys through a series of nil-strength and hot ductility tests.

A Gleeble 3500 system has been installed by **USX Corporation—U. S. Steel Group** ("U. S. Steel") at its research facility in Monroeville, PA.

The Gleeble 3500 at U. S. Steel will be used for welding research and hot workability studies of various steel products. Additionally the machine is configured with an optional laser measurement system to be used for precise non-contact dilatometry studies.

Gerdau Acos Fino Piratini, a specialty steel company in Charqueadas, Brazil, has purchased a Gleeble 3500 for installation at its plant.

The Gleeble 3500 at Gerdau will be used to simulate and study rolling, casting, and forging processes used to manufacture the company's products.