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The Gleeble® NEWSLETTER

Winter 1998–99

Brazilian Steel Company Selects Gleeble 3500 for Materials Studies

A Gleeble 3500 system has been delivered and installed at USIMINAS Research Center in Ipatinga, Brazil. This is the first Model 3500 installed in South America.

The Gleeble 3500 at USIMINAS Research Center is equipped with a Hydrawedge® and a hot torsion system. It will be used primarily for the development of the steels to be produced in the new continuous annealing line under construction at the plant in Ipatinga. USIMINAS is increasing its production of cold rolled steels by 1M ton/year, mainly continuous annealed sheet for the automotive industry. In addition, the Gleeble system is equipped for hot deformation studies and heat treatment research.

"The decision to purchase this equipment is part of the Company's strategy to attend to the ever growing demand for higher quality products. In this sense, the Gleeble represents a competitive differential for USIMINAS," points out Romel Erwin de Souza, the General Manager of the USIMINAS Plant.

Gleeble Application Profiles:

The Gleeble 3500 at the University of Wollongong, Australia

At the University of Wollongong in Wollongong, New South Wales, Australia, research using a Gleeble 3500 is conducted in an atmosphere of close partnership with Australian industry.

In fact, the purchase of the Gleeble thermomechanical simulation system, and its installation in 1997, was made possible by combined funding from the Australian Research Council, University of Wollongong, BHP Steel, the Australian Nuclear Science and Technology Organization (ANSTO) and the Cooperative Research Center for Materials Welding and Joining (CRC-MWJ).

The Gleeble is giving undergraduate, graduate, and post-doctoral students an opportunity to pursue both practical and fundamental research with a state-of-the-art system for simulation of a wide range of metallurgical processes. Graham Hamilton, Materials Engineer and Facility Manager for the Gleeble, says, "This is really good for the students because they get real world experience that, in turn, gives them a good shot at real world positions when they leave the university."

Hamilton adds, "When we're doing work on the Gleeble, we're usually working with industries that have real problems to solve."

For example, the CRC-MWJ is interested in the welding of gas pipelines, in which the main problem is weld embrittlement. In the field, a team of welders lifts the pipes to be welded off the ground. They run a welder around the joint to tack

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Professor Brendon Parker, Dean of Engineering at the University of Wolongong, is seated at the PC while Dr. Michael Ferry, Lecturer in Physical Metallurgy, Department of Materials Engineering, tends to the Virtual Panel Meter on the Gleeble 3500.

Recent Gleeble Papers

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The Effect of Hot-Working Conditions on the Austenite Decomposition in SAE 4120 Steel

by E.B. Damm, C.J. Van Tyne, S.W. Thompson, and D.K. Matlock

The hot-working characteristics of an SAE 4120 steel were evaluated with cylindrical compression tests on a Gleeble 1500. Compressive flow stress and final room temperature microstructures were obtained as a function of hot-working temperature (815°C to 1010°C), strain rate (–0.1 s^{-1} to –10.0 s^{-1}), total true strain (–0.5 to –2.0), and post-deformation cooling path. The experimental variables which were studied physically simulated typical industrial deformation conditions. Industrial cooling profiles were obtained by direct measurement on production forgings and were experimentally simulated as part of the testing. Austenite decomposition temperatures during cooling were determined from dilatometric measurements on both undeformed specimens and hot-worked specimens. The room-temperature microstructures of these specimens were quantitatively analyzed. Data for the austenite time-temperature-transformation decomposition curves were determined for each of the deformation and cooling conditions. The temperature for the start of the ferrite + pearlite reaction was increased as compared to undeformed specimens. With an increase in the hot-working strain rate, and/or a decrease in the hot-working temperature, the time required for the start of the polygonal ferrite + pearlite reaction decreased. A simple relationship is presented which relates the condition of deformed austenite, as measured by the saturation flow stress of austenite, to the observed polygonal ferrite + pearlite transformation start temperature. Microstructural maps which relate the volume fraction of room-temperature microconstituents to the condition of deformed austenite as well as the subsequent cooling path are also presented.

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Effect of Titanium Nitride Precipitates on the Weldability of Nitrogen Enhanced Ti-V Microalloyed Steels

by F.C. Liao, S. Liu, and D.L. Olson

Within the one to three kJ/mm welding heat input range, high nitrogen content (130 ppm) did not impair the weldability of titanium-vanadium microalloyed steels. In fact, the coarse-grained heat-affected zone (CGHAZ) toughness of the high nitrogen steel was superior to that of the low nitrogen (30 ppm) steel welds. At 50 ft-lb (68 J) impact energy, the transition temperatures were, in general, 15 to 60°C lower for the high nitrogen steel CGHAZ. Quantitative metallography results and Charpy-V-notch toughness data showed that the final HAZ microstructure of the high nitrogen steel exhibited fine prior austenite grain size and contained approximately 70 volume percent of ferrite with second phase, balanced with ferritic products. Carbon replicas extracted from the high nitrogen steel showed a large number of fine, cubic or rectangular-prism shaped, titanium nitride precipitates, and these controlled effectively the austenite grain size. The average austenite grain size was approximately three times smaller than that of the low nitrogen steel, e.g., 50 and 170 µm at 1350°C, respectively. The TiN particles in the high nitrogen steel CGHAZ were also found to be more resistant to dissolution with increasing temperature. When heated from 820 to 1350°C, the precipitate population density decreased from 5.3×10^6 to 4.3×10^6 mm^{-2}. On the other hand, in the low nitrogen steel CGHAZ, some larger, irregular-shaped titanium oxide particles were extracted. Under similar conditions, the low nitrogen steel specimens experienced a more drastic decrease in precipitate population density, from 5.1×10^6 to 1×10^6 mm^{-2}. Considering the thermal and processing history applied to the high nitrogen steel, most TiN particles of diameter smaller than 420 Å were found to locate at the prior austenite grain boundaries. Therefore, the coarsening mechanism of these smaller sized TiN precipitates at the grain boundary was determined by grain boundary diffusion. However, short holding times and at high temperature, such as those found in welding thermal cycles, titanium and nitrogen atoms were supersaturated in the matrix. Those particles larger than 420 Å and located inside the austenite grains coarsened by direct precipitation from the supersaturated matrix. The hyperstoichiometric N/Ti ratio is the driving force for more TiN precipitation and that surface energy decrease is the driving force for the dissolution of small TiN precipitates.

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Investigation of Microstructural Evolution in the Forging of Superalloy Disks

by Gangshu Shen and Rajiv Shivpuri

In the forging of superalloy turbine engine disks, control of resultant grain size by thermomechanical processing is a major objective. This paper presents the development of a methodology (1) to obtain the minimum strain corresponding to uniform recrystallized grain via process simulation and micrographs obtained from compression tests; (2) to correlate the relationship between observed recrystallized grain structures with the Zener-Hollomon parameter Z, or the temperature compensated strain rate; and (3) to determine the forging parameters which can provide both desired grain size and the uniformity of distribution at the same time by using the relationship of ln (Z) to (a) recrystallized grain size and (b) the minimum strain corresponding to uniform recrystallized grain. This investigation couples process modeling with physical metallurgy and provides useful information on the control of grain size in the forging of Waspaloy disks.

University of Birmingham Selects Gleeble 3500 for Net Shape Manufacturing Research

A Gleeble 3500 system has been delivered to the University of Birmingham in Birmingham, England.

The Gleeble 3500 was purchased as part of the Net Shape Manufacturing Laboratory at the University of Birmingham. The main use of the Gleeble 3500 will be to support research in net shape manufacturing. This will result in quicker and more cost-effective designs due to more accurate predictions and modeling being possible.

Some of the areas of research include investigating the effect of:

- forging conditions (temperature, percentage deformation, deformation rate, cooling rate, etc.) on the microstructure of machinable forging steel grades.
- heat treatment cycles and forging/rolling deformation reductions on the mechanical properties and microstructure of aerospace steels for use as aircraft undercarriage materials.
- residual stresses from the welding process on microstructural evolution and mechanical properties in the weld heat affected zone of structural steels.
- cleavage initiation from competing potential initiation sites in the weld heat affected zone of structural steels.

The Gleeble 3500 is capable of heating specimens at 10,000°C/second and applying loads as high as 10 tons of force.

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.

ASM INTERNATIONAL ®

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:

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Conference Announcements

DSI will participate in the following conferences in 1999 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.

Topics to be covered at this conference include:

- Fundamentals and mechanisms of recrystallization
- Development of inhomogeneous microstructures during deformation
- Grain boundary migration and growth
- Experimental methods of investigation of recrystallization
- Computer simulations and modeling
- Recrystallization and related phenomena in thin films and coatings
- Applications to materials processing

For more information contact:
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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.

The symposium will provide a forum for exchange of ideas, information and presentation of papers dealing with physical simulation and numerical (computer) simulation and their application to materials and hot working, as well as primary theories of physical simulation and its prospects in the 21st century. Official proceedings will be published in English in October 1999 (ACTA METALLURGICA SINICA, No. 5, 1999).

The abstracts of papers (about 300 words) should be sent to professor Jitai Niu, the co-chairman of the organization committee of the conference, by April 1, 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. The scope of the Congress will include forging processes, testing, inspection, heating, heat treatment, quality assurance, quality control, die making (CAD/CAM), and research project equipment. Dr. Wayne Chen from DSI will present a paper titled: "Optimizing Hot Forging Processes of Difficult-to-Forge Materials."

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The Gleeble at the University of Wollongong

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the two pipes together, then go around again with the welder to create a good joint between the two pipes.

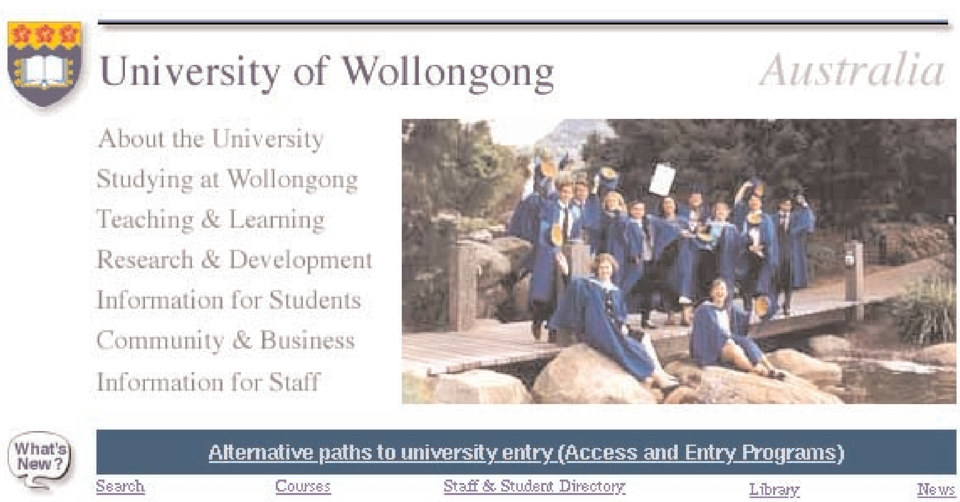
If they weld too quickly or use the wrong welding rods, they run the risk of weld embrittlement which may subsequently fail in a few months, even though it passed all the initial leak testing. The work on pipe welding using the Gleeble at the University of Wollongong focuses on the production of a better steel composition that will be highly weldable and will not be subject to embrittlement. Additional work also focuses on finding the right welding rod material for each steel composition.

Another major project involving Gleeble research at Wollongong, and led by Dr. Mike Ferry and Prof. Brendon Parker, is an investigation of steel production using direct hot charging from the continuous caster to the hot rolling mill. As the steel comes out of the caster it is very near the melting point and in the nil-ductility area. One of the questions the researchers want to answer is: at what stage can they start hot working the steel? Too soon, and it will start to tear; too late, and you fail to conserve as much energy as possible. Finding the answer to this question will save both energy and money. A further question is the effect of hot direct rolling on microstructural evolution and its influence on properties. One highly proprietary project concerning continuous casting involves simulation of thin strip casting and hot rolling, with the aim of understanding how to integrate thin strip casting and direct rolling to create a finished product with desirable properties.

Another research problem under investigation, which uses the hydrawedge compression system, relates to hot rolling of alloy steels. How much reduction can be achieved on each pass with new grades of steel before defects start forming? How many passes will be necessary to obtain the desired product? What combination of deformation temperature, strain, strain rate and interpass time will produce a given grade of steel with optimum properties?

The Gleeble is used for a wide range of other projects concerned with processing of metallic alloys, such as the potential use of magnesium for car engine blocks, high-rate annealing of cold rolled aluminium and steel strip, and thermomechanical processing of aluminium alloys. An investigation has been carried out by Mike Ferry on the deformation behavior of aluminum single crystals at high strain rates and temperatures. This project is concerned with microstructural stability of certain crystal orientations over the conditions encountered during hot rolling.

At the University of Wollongong, the Gleeble serves two important purposes: it is a tool for finding answers to urgent materials problems and an important means of developing materials scientists and engineers who will keep Australian industry at the cutting edge of technology advancement for years to come.



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