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The Gleeble® NEWSLETTER
Fall 2003

DSI at the Shows

ICPNS 2004 Set for May 17–20, Shanghai, China

The 4th International Conference on Physical and Numerical Simulation of Materials Processing—originally scheduled for May 2003, and postponed because of SARS concerns—has been rescheduled. The Conference will be held at the Novotel Shanghai Yuan Lin Hotel, Shanghai, China, from May 17–20, 2004.

At present, about 320 delegates from 30 countries have submitted abstracts or manuscripts of papers. For additional information about attending or presenting at the conference, visit http://nsmp.hit.edu.cn or contact:

Professor Jitai Niu (Chairman of the conference)
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Harbin Institute of Technology
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SimPro '04, September 21–23, Ranchi, India

An International Conference on Thermo-Mechanical Simulations and Processing of Steels—SimPro '04—is scheduled for Ranchi, India, September 21–23, 2004. The conference, organized by the R&D Centre for Iron and Steel and the Indian Institute for Metals, is sponsored by the Ministry of Steel and

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Gleeble Application Profile

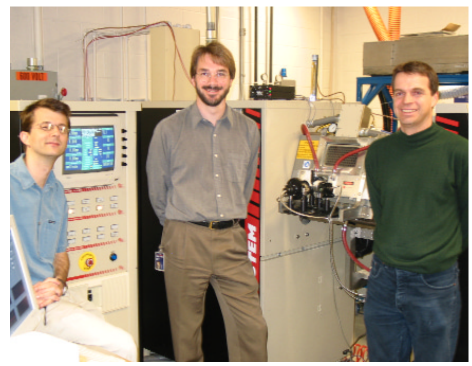
The Gleeble at the National Research Council of Canada

A specially modified Gleeble 3500 is at the heart of an exciting research program now underway in the Modelling and Diagnostic Section of the Industrial Materials Institute of the National Research Council of Canada.

In a ground-breaking study, Martin Lord, Technical Officer, and Research Officers Silvio Kruger and André Moreau are developing a system that allows non-contact measurement of elastic moduli, crystallographic texture, phase fraction, and grain size in a sample while it is undergoing transformation. The two researchers refer to this as "real-time metallography."

The system under development involves generating and detecting ultrasound in a sample under test with lasers. To generate the ultrasound wave in the sample, a high-power, short-pulse laser produces light pulses of a fraction of a Joule of energy and about 10 nanoseconds duration. These pulses ablate the surface of the sample a tiny amount (of order nanometers), cause pressure on the surface of the sample, and send a pressure acoustic wave through it.

To detect the ultrasound wave in the sample, a laser interferometer measures tiny amounts of surface displacement with subnanometer resolution by making the laser light from a second laser interfere with itself. This second laser is a Nd:YAG laser that generates 1 kilowatt of instantaneous power for 50 microseconds, which is long enough to do complete ultrasound experiments within the sample as the ultrasound wave bounces back and forth several times within the sample. Since the ultrasonic wave travels 5–6 millimeters per microsecond, the 50 microsecond detection pulse is a long time. The two lasers are synchronized and fired up to



From left: Silvio Kruger, André Moreau and Martin Lord conduct research using a modified Gleeble 3500.

100 times per second, providing essentially real-time monitoring of microstructure changes for most practical metallurgical engineering problems.

The loss of amplitude and the time between the various ultrasonic echoes gives the researchers the attenuation and velocity of the ultrasound wave. The velocity depends on the material under test; it will be different for iron or aluminum. The velocity is also a measure of the elastic modulus, which varies with temperature and phase transformation. So by careful measurement of velocity, the researchers can quantify phase transformations.

They can also measure the texture of the sample. If they know that some crystallographic orientation is normal to the sample surface and produces a certain velocity, they know that changes in the crystallographic orientation will alter that velocity. As a result, they can compute the average orientation distribution from velocity measurements.

Grain size is another parameter that

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Recent Gleeble Papers

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Modeling of Developing Inhomogeneities in the Ferrite Microstructure and Resulting Mechanical Properties Induced by Deformation in the Two-Phase Region

by J. Majta, A.K. Zuek, and M. Pietrzyk

The differences in microstructure development of hot deformed steels in the austenite and two-phase region have been effectively described using an integrated computer modeling process. In general, the complete model presented here takes into account kinetics of recrystallization, precipitation, phase transformation, recrystallized austenite grain size, ferrite grain size, and the resulting mechanical properties. The transformation submodel of niobium-microalloyed steels is based on the nucleation and grain growth theory and additivity rule. The thermomechanical part of the modeling process was effectively carried out using the finite element method. Results were obtained in different temperatures, strain rates, and range of deformation. The thermomechanical treatments are different for two grades of niobium-steels to make possible analysis of the resulting structure and properties for different histories of deformation and chemical composition.

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Particle Stimulated Nucleation following Deformation at High Strain Rate and Temperature

by N. Stanford and M. Ferry

An Al-Si alloy, heat treated to produce a uniform dispersion of coarse (~4 μm) Si particles in a high-purity aluminum matrix, has been deformed in plane strain compression to a true strain of 1.4 at true strain rates in the range 0.5–50 s^{-1} at temperatures up to 500°C. As-deformed specimens were subsequently annealed at 300°C to study the effect of hot deformation parameters on nucleation sites, recrystallization kinetics and recrystallized grain size. The mechanical behavior of the alloy was shown to fit the Sellars-Tegart constitutive relationship with an activation energy close to that of the bulk diffusion in Al. Analysis of the annealing behavior of the alloy indicated the critical particle diameter for particle stimulated nucleation (PSN) is dependent on flow stress (and Zener Hollomon parameter) and correlates closely with theoretical prediction.

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Dynamic Mechanical Behaviors of As-Cast Stainless Steel 1Cr25Ni20Si2 During Hot Deformation

by H.Y. Leng, K. Yang, and W.X. Han

The dynamic mechanical behaviors of as-cast 1Cr25Ni20Si2 austenite stainless steel during hot deformation have been studied using a Gleeble 1500 hot working simulator. The hot deformation equation, the deformation activation energy, the criterion of occurring dynamic recrystallization, and the relationship between peak strain and peak stress have resulted through the experiments.

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Modelling of Microstructure Evolution and Properties of Low-Carbon Steels

by M. Militzer

The microstructure evolution has been investigated for hot rolling of advanced low carbon steels containing Nb, Ti, V and Cu. The critical processing step to develop the properties of hot rolled steels is cooling after rolling when the austenite-to-ferrite transformations as well as precipitation takes place thereby determining the final microstructure. Thus, the modeling work emphasizes the kinetics of ferrite formation. Ferrite growth rates can adequately be described by taking into account a solute-drag-like effect of Mn and Nb. The emphasis of the model is to predict the phase transformation kinetics for the industrial practice of accelerated cooling. The ferrite grain size is essentially determined at the early stages of transformation and can be correlated to the transformation start temperature. Carbides and nitrides of Nb, Ti and V are controlled by Ostwald ripening of these particles. The aging behavior can then be described based on the Shercliff-Ashby model for precipitation hardening. The situation is more complex for Cu precipitation where the aging response is also related to a sequence of different precipitation types.

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Simulated Research on Hot Forming Mechanism of 35CrMo Steel

by X.H. You, Q.L. Zhang, and H.G. Guo

The significance of this paper lies in the application of bending-upsetting 35CrMo steel in train crack-shaft. The hot deforming tests of 35CrMo steel have been done on the Gleeble 1500 testing machine with the deformation temperature at the range of 900–1250°C, a strain rate of 0.05 s^{-1}, 0.5 s^{-1}, 1.0 s^{-1} and compress degrees of 15%–80%. Through respectively analyzing and studying the microstructure of the specimen and getting the data from the testing, the results obtained are as follows: the model of flow stress and the stress-strain relationship of material hot deformation, the model of dynamic and static re-crystallization and the correlative references of hot forming parameters and changes of microstructure. The hot deforming stress-strain curves and relevantly recrystallized microstructure of 35CrMo steel are drawn at the deformation temperature of 1250 and the strain rate of 1.0 s. Through analyzing and regressive calculation of the grain size of the deformation specimen of 35CrMo steel at different locations under the large-deformation and high-temperature conditions, the hot-deforming model of grain calculation is verified. The experimental results and the model of grain calculation can provide scientific basis for analyzing the hot deformation processes and controlling quality.

The Gleeble at NRC Canada

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can be measured. If you have a continuous medium and an object embedded in it, the object will scatter the ultrasound. The larger the object is compared to ultrasonic wavelengths, the more scattering will result. Because each grain is like a scattering object, the larger the grain size, the more loss of amplitude will be observed. As a result, the measurement of attenuation is also a measurement of grain size.

Through this technique, the Canadian researchers can measure the grain size and growth at temperature of the austenite phase in steels. Previously, only time-consuming and sometimes complex metallographic analysis of quenched samples was used to evaluate former austenitic grains, and steelmakers have long wished for such a real-time technique since the austenitic grain size at high temperature is very important for the properties of the steel at room temperature.

The potential commercial applications of this technology are very interesting. For example, a manufacturer with a process that involves high mechanical deformation, such as rolling, frequently anneals the metal after rolling to recrystallize the microstructure for the final application. In nearly all cases, recrystallization involves a change in texture. By measuring the fractional change in texture during annealing, the researchers can measure the recrystallized fraction. Right now, such measurements are usually done by interrupting the annealing cycle, quenching, and examining a sample through x-ray diffraction or metallography. This lengthy procedure yields a single data point on the time dependence of recrystallization. In contrast, the laser-ultrasonic technique developed at IMI yields an entire curve in a single run.

With the Canadian non-contact laser-ultrasonic system, it may some day be possible to monitor the production annealing line in real time to make sure that the ultimate product will have the desired properties. Indeed this has been demonstrated already in a pilot experiment at the

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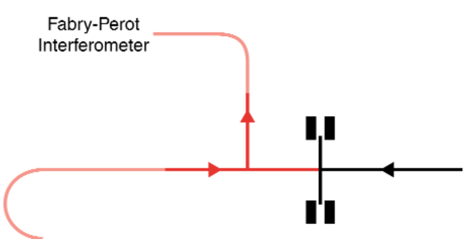
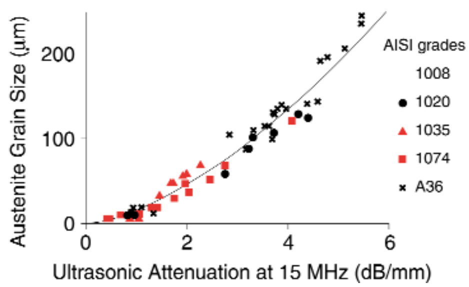
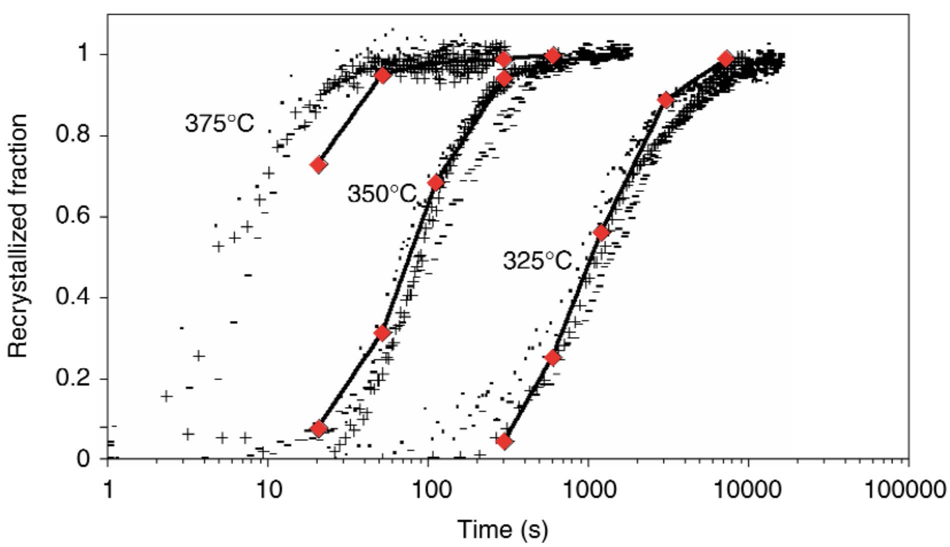


Instrumented Gleeble thermomechanical simulator.



Empirical calibration: Austenite grain size vs. attenuation at 1100°C.



Recrystallization kinetics of 60% cold rolled AA6111 measured using ultrasonics (dots, pluses, dashes) and mechanical tests (red diamonds).

DSI at the Shows

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DSI and is co-sponsored by CBMM Asia Co., Ltd. and Concast India Limited.

The conference will focus on:

- Simulation of continuous casting, hot rolling, strip annealing, forging, extrusion, heat treatment, and welding/HAZ
- Phase transformations
- Modeling of metallurgical processes
- Advances in thermomechanical processing for hot rolled, cold rolled, and coated steels
- Emerging steel products, processes and applications for the 21st century.

The conference will be held at the Auditorium of Research & Development Centre for Iron & Steel (RDCIS)—a Corporate R&D Centre of SAIL which is the largest steel producer in India. The R&D Centre is equipped with state-of-the-art testing and diagnostic facilities including pilot scale laboratories to carry out comprehensive research and developmental activities for various units of SAIL.

For additional information about SimPro ’04, contact:

Conference Secretariat
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Gleeble Demonstration

Experts from Dynamic Systems Inc., USA, manufacturers of the Gleeble thermomechanical physical simulation system, will be available for interaction and discussions with the participants. A live demonstration of the Gleeble 3500C will also be organized during the conference.

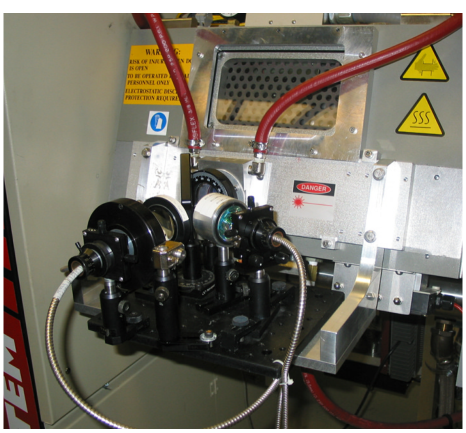
Dynamic Systems Inc.
P.O. Box 1234, 323 Route 355
Poestenkill, NY 12140 USA

Special Modifications to the NRC Gleeble

Modifications to the Gleeble 3500 at the National Research Council in Boucherville, Canada were made to enable the customer to test sheet specimens with their existing laser gauging equipment. The front and back doors of the vacuum tank were modified to mount adjustable laser ports to let the laser beams pass through the center of the vacuum tank. These ports are adjustable along the length of the specimen, to allow for varying specimen lengths as well as analysis of different positions along the specimen. The glass in the port is mounted perpendicular to the ground and parallel to the orientation of the specimen.

The laser ports are water-cooled to ensure they would not overheat during the test. The final item that was added to the laser port mounts was a series of holes, allowing the customer to mount a bracket holding a variety of lenses and optics packages to the front and back doors of the vacuum tank to control shape and optical characteristics of the laser beams.

The modifications to the inside of NRC's vacuum tank involved rotating the pocket jaws so that the samples are conveniently mounted vertically and perpendicularly to the (horizontal) laser beams. IMI uses two sets of hot flat grips: copper for high heating rates, and stainless steel for better temperature uniformity in the hot zone.

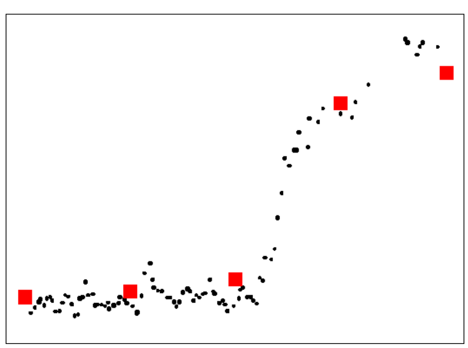


Adjustable laser ports were mounted to the Gleeble's vacuum tank.

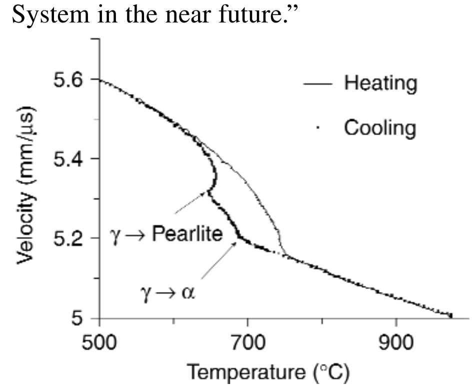
The Gleeble at NRC Canada *Continued from Page 3*

Commonwealth Aluminum Corporation. For the manufacturer, the ultrasonic system would simply become a sensor that tells whether the annealing system is doing its job or not. Another application could monitor the phase transformation among the austenite, ferrite, and pearlite phases of steels—in real time on the production floor.

Silvio Kruger says, "This is why we bought the Gleeble system in the first place, to develop ultrasonic sensors. We wanted a machine that would simulate online conditions so that we can test our system in the laboratory. No other physical simulation system could do the job for us. The combination of the Gleeble 3500 and our test sensors is really something." He adds, "Presently, the performance of a cost-effective laser-ultrasonic system is being tested in our laboratory and we expect that metallurgists could benefit from an add-on laser-ultrasonic measurement system to use with their Gleeble System in the near future."



Austenite grain growth in A36 steel during heating.



Phase transformations in 1035 steel during heating and cooling.