



**Dynamic Systems Inc.**

Tel: (518) 283-5350 Fax: (518) 283-3160

Internet: [www.gleeble.com](http://www.gleeble.com)

E-mail: [info@gleeble.com](mailto:info@gleeble.com)

# The **Gleeble**<sup>®</sup>

## NEWSLETTER

Winter 2001–2002

*Preliminary Announcement*

### **THERMEC 2003 International Conference on Processing and Manufacturing of Advanced Materials**

Building upon the proven success of its predecessors (THERMEC 2000 attracted 460 participants from 32 countries), THERMEC 2003 is now planned for July 7–11, 2003 in Madrid, Spain.

THERMEC 2003 will focus on recent advances in the overall field of science and technology of fabrication and manufacturing, structure and properties, and applications of both ferrous and non-ferrous materials, especially alloys of Al, Mg, Ti, Fe-C, Fe-C-Ni. Emphasis will also be given to other advanced materials such as metal-matrix composites, intermetallics, metallic amorphous materials, superalloys intelligent/smart materials and powder metallurgy/particulate materials.

Special sessions will be devoted to severe plastic deformation, surface engineering/coatings, modeling, texture, superplastic deformation, residual stresses, welding and joining, thin films technology and nano-materials/nano tubes. Technical presentations will consist of invited papers by experts from around the world, with papers by others working in relevant fields.

The first circular for THERMEC 2003 will be mailed in March 2002.

*Continued on Page 3*

### Gleeble Application Profile

## **The Gleeble and MAXStrain System at Delft University of Technology**

At Delft University of Technology, they're serious about being on the cutting edge of metals research. That's why, jointly with Dutch industry, the University set up the Netherlands Institute for Metals Research (NIMR) to deal with today's changing global market. NIMR provides collaborative research between the University and industry, which the Dutch government backs.

For some time now, NIMR has had a Gleeble 3500—"one of the best Gleeble facilities in Europe for research within the thermo-mechanical area, which is constantly being upgraded to keep the facility up-to-date," according to Thim Zuidwijk, NIMR technician who is chiefly responsible for operation of the Gleeble. Recently, however, NIMR upgraded its Gleeble with the installation and commissioning of a MAXStrain Multi-Axis Deformation Mobile Conversion Unit.

The addition of the MAXStrain unit is part of a two-year project undertaken jointly by NIMR and CORUS, a Dutch and British steel producer, under the leadership of Professor Sybrand van der Zwaag. The goal is to increase the strength of aluminum alloys and steels, to be used by the automotive and aerospace industries, by refining the grain size.

"The project involves continuous contact with CORUS," says NIMR's Dr. Ali Gholinia. "The alloys are supplied by them, and there is a lot of collaboration with their facilities."

"The goal," Dr. Gholinia says, "is to produce steel and aluminum alloys with high strength, good ductility, high fatigue resistance, and which are designed for superplastic forming. Basically, we want to find out how to produce ultrafine grain in industrial-size feedstock."

*Continued on Page 3*



*Dr. Ali Gholinia, left, and Thim Zuidwijk prepare a test on the Gleeble 3500 at Netherlands Institute for Metals Research.*

# Recent Gleeble Papers

364

## Physical Simulation to Determine High Temperature Mechanical Behavior of Continuously Casting Steels

by Zijiu Dang and Yan Zhang

The present work was undertaken to obtain a better understanding of high temperature mechanical behavior of continuously cast (CC) steels. Hot ductility and strength of CC steels at elevated temperatures from CC processes were studied by physical simulation. The ideal method is the hot ductility test. This paper discusses two related subjects which are the design of test parameters and data interpretation in the methodology. The bulging of CC steel slabs which is caused by the mechanism of creep has great influence on the formation of central segregation and internal cracks. Creep tests, including static creep tests and dynamic creep ones, were performed at high temperatures, 1200°C and 1300°C in this study. Effects of strain rate and temperature on hot ductility are also discussed and a simple model is presented explaining the interaction between hardening and softening.

365

## Simulation of Liquation Cracking in High Frequency Induction Welding of Aluminum Alloy

by Taketoshi Doko, Hiroaki Takeuchi, Takahiro Kumazawa, and Atsuo Kikuchi

Liquation cracking in high frequency induction welding of aluminum alloy was simulated by using Gleeble test machine. The flow stress at elevated temperatures of aluminum alloy was investigated by the plane strain compression test at a strain rate of 10/s. Specimens were cracked at temperature close to their melting points. By the investigation of fracture surfaces and microstructures around the cracks by plane strain compression test were found to be similar to those by high frequency induction welding. The relationship between flow stress and temperature in

the temperature range in which specimens were not cracked is represented by the following equation.

$$\sigma n = A_{\text{exp}}(Q/RT)$$

$\sigma$ : flow stress,  $n$ : constant,  $A$ : constant,  $Q$ : activation energy for hot working,  $R$ : constant,  $T$ : absolute temperature

The flow stress at temperature with occurrence of cracking was lower than the flow stress extrapolated from the relationship between flow stress and temperature in the temperature range in which specimens were not cracked. It was considered that cracking sensitivity could be estimated by comparing the flow stress at temperature with cracking of the extrapolated flow stress.

356

## Recrystallization Behavior of 12% Cr Ferritic Stainless Steels as Revealed by the Stress Relaxation Technique

by L. Pentti Karjalainen, Juha S. Perttula and Joni A. Koskieniemi

For improving the mechanical properties of new low-carbon, essentially ferritic stainless steels containing 11–13% chromium, the final grain size should be refined by proper thermomechanical processing. Knowledge of the softening behavior is essential for the modeling and precise control of the hot rolling process. A newly established technique of stress relaxation was used on a Gleeble 1500 simulator for investigating the static recrystallization kinetics in hot-deformed austenite of 12% Cr type steels. The effects of the deformation variables and the presence of the ferrite phase at the deformation temperatures was investigated and a regression equation representing the recrystallization rate was formulated. The observed effects of strain, strain rate, and temperature were close to those in conventional austenitic stainless steels, but the recrystallization rate is significantly faster. Hot rolling should take place at low

temperatures of 800–850°C with a final pass of about 30% in order to accelerate austenite decomposition and effectively refine the final grain size. The ferrite phase strongly promotes recovery, preventing the recrystallization of austenite, which is sensitively revealed by the stress relaxation behavior. It seems that the law of mixture model is more accurate in predicting the softening of deformed prior-partially-recrystallized austenite than the uniform softening model, which overestimates the softening rate.

357

## Characteristics of Static and Metadynamic Recrystallization and Strain Accumulation in Hot-Deformed Austenite as Revealed by the Stress Relaxation Method

by L. Pentti Karjalainen and Juha Perttula

The newly established technique of stress relaxation has been applied to measure the kinetics of static and metadynamic recrystallization of austenite in a low-carbon steel subsequent to compression executed at a strain rate of 0.1 or 0.01s<sup>-1</sup> at 900°C or 1000°C. The characteristics of static recrystallization were found to be consistent with those previously reported from double-stage deformation tests. Metadynamic recrystallization, contrary to static one, showed no dependence on strain and hardly any on temperature, but significant dependence on strain rate. The Avrami exponents were almost identical for the two processes, about 1.5–1.6 at 0.1s<sup>-1</sup>, but decreased to 1.0–1.3 at 0.01s<sup>-1</sup>. Metadynamic recrystallization resulted in complete softening except when relaxed after compression to a strain of 0.3 or beyond at a low strain rate of 0.01s<sup>-1</sup>. The law of mixtures approach was found to be more accurate than the uniform softening model to describe recrystallization in partially recrystallized and subsequently deformed austenite. The results confirm the feasibility of the stress relaxation technique as an efficient method for investigating recrystallization kinetics in hot-deformed austenite.

# Extended Maintenance and Service Programs Available

At DSI, one of our top priorities is customer satisfaction. Our goal is to provide you with leading edge technology, quality manufactured machines, followed by premium customer service. One way we do this is through maintenance programs which sustain constant contact between you and our service and metallurgical engineers. The result is that we work together to maintain maximum up-time and productivity of your Gleeble.

Here are some of the benefits of the various extended maintenance programs we offer:

- Unlimited telephone, fax and email hot line support for applications and operation assistance
- Instant technical phone support during normal business hours Monday–Friday
- Priority response to faxes and emails
- 24-hour access to DSI's customer support technical website
- Minimized system downtime and unexpected outages
- Up-to-date versions of critical software

- Replacement/repair parts typically shipped within the next business day
- Annual machine factory tuning and calibration
- Service by factory trained engineers
- Factory replacement parts specifically designed for Gleeble systems
- Extended machine life due to regular maintenance
- Reduced maintenance costs
- Peace of mind

To help you maintain maximum up-time and productivity with your Gleeble system, DSI offers four different maintenance and service programs.

## The Type I Factory Maintenance Program—for All Gleebles

Provides repair or replacement components. There is no on-site service included in the Type I program. Any on-site service must be purchased separately at regular service rates. Should on-site service be purchased, the cost of any covered parts

*Continued on Page 4*

## The Gleeble at Delft University of Technology

*Continued from Page 1*

He adds, "The process is not well understood. It involves reversal of the strain path, which makes the process very complex. With the MAXStrain load unit, the specimen is rotated and strain is applied in a different direction while it is constrained."

"As a result," he says, "it is possible to achieve a strain of 10 or more. That's equivalent to compressing material that is 300 meters thick down to only 15 millimeters. In normal rolling, the highest strain would be around 4."

While high strain testing is conducted on the MAXStrain-equipped Gleeble, other branches within NIMR are modeling the technique. Some are creating macro-forming models on a large scale while other researchers are creating models that attempt to simulate and predict the microstructure. The groups meet regularly to coordinate and collaborate.

"We're not just looking at the process," Dr. Gholinia says. "We're also looking at the materials. There are a huge variety of materials, and we're trying to look at how the different compositions have an effect on the processing of the microstructure.

We have to understand what's happening so that we can do proper experiments, the results of which will be used to feed the computer models."

At NIMR, the Gleeble is kept extremely busy. In addition to the ultra-fine grain project, there are other collaborative projects that demand time on the Gleeble: simulation of direct chill casting for the aluminum industry, rolling process simulations for steel and aluminum producers, and tensile testing or property improvements in aluminum alloys.

NIMR together with DSI are organizing an ultra-fine grain workshop to be held at Delft, The Netherlands in April 2002. Details can be obtained from the NIMR head office at, Rotterdamseweg 137, P.O. Box 5008, 2600GA, Delft, NL.

Dr. Gholinia says, "The Gleeble gives us simulation and test capabilities that are simply unavailable on other equipment. From our point of view, DSI is a good company to work with: small enough to be flexible, large enough to deliver what we need."

Gleeble and MAXStrain are registered trademarks of Dynamic Systems Inc.

## THERMEC 2003

*Continued from Page 1*

If you would like to receive it and additional information about THERMEC 2003, please contact: Professor T. Chandra, Faculty of Engineering, University of Wollongong, Wollongong 2522, Australia. Email: tara@uow.edu.au or fax +61 2 4221 3421.



## Great Reasons to Sign Up for the Electronic Version of the Gleeble Newsletter

1. You'll get the latest news about the Gleeble, Gleeble developments, and Gleeble applications from DSI faster than any conventional means of delivery. (In some locations, the email-delivery version beats conventional mail by two weeks.)
2. Like the printed version of the newsletter, it's free.
3. The electronic version is environmentally friendly.
4. You'll get the exact same editorial content as the printed version.
5. Signing up for the electronic version is easy. Just email [info@gleeble.com](mailto:info@gleeble.com) and tell us you want to receive the electronic version, or sign up on our website, [www.gleeble.com](http://www.gleeble.com).
6. The electronic version, since it uses no paper, will reduce clutter in your office.
7. We don't have to cut down trees or recycle anything to produce the electronic version.
8. By signing up for the electronic version of the newsletter, you position yourself as a forward-thinking trend-setter.
9. The electronic version is easy to share with your colleagues—just forward the email.



**Dynamic Systems Inc.**

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

---

## ***Extended Maintenance and Service Programs Available***

*Continued from Page 3*

used during on-site service are included under the Type I maintenance program.

Components, sub-assemblies, and parts covered by this program will be repaired or replaced free of charge by returning the components to DSI's factory or an alternate site designated by DSI, freight prepaid. In certain instances DSI's replacement parts may be sent to the customer prior to the return of the damaged part in order to keep your Gleeble System operational. The decision to repair or replace a part is at the sole discretion of Dynamic Systems Inc. Unlimited telephone, fax and email hotline support for applications and operation assistance is provided with this program.

### **The Type II On-Site Service and Maintenance Program—for All Gleebles**

Provides for repair or replacement of parts, as provided with Type I Programs, plus on-site service. One on-site service call per year for repair and calibration will be provided at no charge. Service will be scheduled at your request. No credit will be provided for on-site service calls not used during the program. This program does not include computer software or hardware. You may elect to use an on-site service visit for applications seminars and training of customer staff. The total number of days per visit is limited to two. Additional days are available at regular service rates. Unlimited telephone, fax and email hotline support for applications and operation assistance is provided at no charge with this program.

### **The Type III Software Maintenance Program—for Gleebles with Series 3 Digital Control Systems**

Ensures your Series 3 Digital Control system is kept up to date with the most recent version of software for your machine/hardware configuration. Without this plan, software updates must be purchased separately. Type III Software Maintenance Programs are only available for Series 3 digital control systems. Software support for MS-DOS based programs has been discontinued. Hardware updates must be purchased separately as needed. Prior to accepting a contract, DSI will inspect the machine and advise if hardware updates are necessary.

### **The Type IV Premium Coverage Maintenance Program—for Gleebles with Series 3 Digital Control Systems**

Provides for on-site service and parts repaired or replaced. This program is available for Gleebles with Series 3 Digital Control Systems. Two on-site service calls per year for repair and calibration will be provided at no charge. Service will be scheduled at your request. No credit will be provided for on-site service calls not used during the program. You may elect to use an on-site service visit for applications seminars and training of customer staff. The total number of days is limited to six days in any combination over two visits. Additional days and/or visits are available at regular service rates.

Unlimited telephone, fax and email

hotline support for applications and operation assistance is provided at no charge with this program. All software upgrades to maintain the latest versions of software are included. Hardware upgrades to the desktop and embedded control computer are included if they are required to run the latest versions of Gleeble software. This covers upgrades of the computer hardware to the minimum requirements for the latest version of software installed by DSI on the Gleeble System. Prior to accepting a contract, DSI will inspect the machine and advise if hardware updates are necessary.

Type I, Type II and Type IV Programs cover all parts, components and sub-assemblies of the Gleeble Systems, including all options purchased from DSI, with the following exceptions:

- components and sub-assemblies added by the user after installation which are not of DSI's manufacture;
- components, sub-assemblies or options manufactured by DSI which have been modified or altered, unless under the direct supervision of DSI;
- components and sub-assemblies that have been damaged through misuse, neglect, or improper maintenance, and
- routine expandable items

When your system is covered by one of these programs, Dynamic Systems Inc. will make every effort to dispatch a service engineer or replace or repair parts in a timely and efficient manner. For complete details on these programs, including any conditions and exclusions, contact us at DSI.