Dynamic Systems Inc.
Tel: (518) 283-5350 Fax: (518) 283-3160
Internet: www.gleeble.com
E-mail: info@gleeble.com

The Gleeble® NEWSLETTER
Summer 2000

Model 39018 CCT Dilatometer Debuts

A new dilatometer transducer offering both wide range and high accuracy is now available from DSI. The Model 39018 CCT dilatometer transducer is an LVDT-based unit that can be used for measuring phase transformations with and without deformation on a variety of materials and specimen sizes within the limits listed below. This model can be used on Gleeble 3500, 3800, 3200 systems and Gleeble 1500 systems equipped with a Series 3 digital control update.

The Model 39018 features coarse and fine adjustments for quartz measurement tip pressure, which helps to maintain accuracy in tests at high temperatures. Generally, this dilatometer is recommended for use in tests with deformation rates up to 10/sec. Higher deformation rates may require use of a non-contact measurement method. Another feature of this dilatometer transducer is the use of 3 mm diameter quartz contact rods (other DSI transducers use 5 mm diameter rods). The smaller diameter quartz rods allow for larger deformations in each test than previous designs.

Specifications

Linear Range
± 2.5 mm (0.1 inch)
Linearity
± 0.25% full scale
Specimen Size
5 mm to 16 mm (0.2 inch to 0.625 inch) diameter depending on quartz rod configuration.

Continued on Page 3

Gleeble Application Profile

The Gleeble at the University of Birmingham, England

The Net Shape Manufacturing Laboratory, associated with the Interdisciplinary Research Centre in High Performance Materials at the University of Birmingham, has a mission: to provide world class research and development into the cost-effective and environmentally-responsible net shape manufacture of metallic, ceramic and polymeric components, and to transfer the results to industry. The Gleeble 3500 was purchased to support the research programs in net shape manufacture by providing accurate materials data to use in process models.

For Dr. Claire Davis, lecturer in metallurgy and materials, and her colleagues at the University of Birmingham, the Gleeble 3500, which was installed nearly a year-and-a-half ago, is a powerful research tool for helping to achieve those aims. "Lots of different people use the Gleeble to support their research," Dr. Davis says, "including research graduate students and post-doctoral researchers as well as people from outside the University, such as other universities and companies."

Examples of research carried out to support net shape manufacture include using the Gleeble's thermo-mechanical capabilities to examine forging deformation behavior on the mechanical properties of a range of materials: steels, nickel based alloys, titanium alloys and even plasticene

Continued on Page 4

Dr. Claire Davis, lecturer in metallurgy and materials at the University of Birmingham, and Ph.D. candidate Mayorkinos Papaelia prepare for a simulation on the Gleeble 3500.

Recent Gleeble Papers

341

Development of a Mo-B-Ti Type High Toughness Wire for Pipelines

by Zuze Xu, Shilin Jin, Xiren Yao, and Xiuting Tian

This paper introduces primarily new Mo-B-Ti type submerged arc welding steel wire with the yield strength of 420–500MPa and possessing the acicular ferrite microstructure after welding and having good impact toughness at temperature as low as –40°C. The wire may be used at highwelding energy and at high welding speeds giving deep penetration. This paper also describes that the steel was smelted in 300 tn LD converter and followed by RH process at Baoshan Steels (Group) Company in China. The wire is clean in chemical composition and it is suitable to weld high strength steels, such as X60-X70 pipeline steels.

346

On the Nucleation Kinetics of Static Recrystallization

by W.P. Sun, E.B. Hawbolt, and T.R. Meadowcroft

Based on the nucleation mechanism of subgrain coalescence and the measured softening data, a kinetic model was developed to predict the start times for the static recrystallization occurring after hot deformation. Both the model predictions and experimental observations indicate that the onset of recrystallization is decelerated as reheating temperature is increased, but accelerated when the deformation temperature is increased. The former is due to the larger initial austenite grain size generated at higher reheating temperatures, which in turn produces larger subgrains and reduces their rate of coalescence. The latter can be explained by the higher boundary diffusivity and mobility attained at higher deformation temperatures, which speeds up the process of subgrain coalescence. The accelerating effects of strain and strain rate can also be attributed to the higher dislocation density and finer subgrains obtained during the higher strain and strain rate deformation. The good agreement between model predictions and experimental results supports the view point that the coalescence of subgrains could be the rate controlling mechanism for the nucleation of static recrystallization.

350

Weld Heat-Affected-Zone Response to Elevated-Temperature Deformation in 2.25Cr-1Mo Steel

by R.J. Bowers and E.F. Nippes

The mechanical response to elevated-temperature deformation was assessed for weld heat-affected-zone (HAZ) and base-metal microstructures in 2.25Cr-1Mo steel. A constant-displacement-rate (CDR) test, capable of determining long-time, notch-sensitivity tendencies, was implemented on a Gleeble 1500 thermal/mechanical simulator and an Instron. Microstructures representative of the coarse-grained, grain-refined, and intercritical regions of the HAZ were simulated on a Gleeble. Microstructural reproduction reflected the preheat and postweld heat treatments in accordance with the required codes. A K_1 analysis of the data was conducted, which showed that small-scale yielding criteria were adhered to throughout the test. The highest K_1 values were found for the base metal. Failure occurred at the peak load for the coarse-grained microstructural region; no K_1 analysis was possible. An empirically derived relationship for CrMoV steels between the displacement-at-failure value in the CDR test and the estimated service life was employed. Both the Gleeble and Instron tests showed the coarse-grained region to have the shortest estimated service life. The test results indicated that the high-temperature extensometer control of the Instron was better able to maintain stable crack growth after peak load than the crosshead control of the Gleeble. The CDR test was seen to be an effective, short-time procedure to delineate and compare the strength and relative service life of the structures present in the weld HAZ.

351

Characterization of Constitutional Liquid Film Migration in Nickel-Base Alloy 718

by V.L. Acoff and R.G. Thompson

When multiphase alloys are rapidly heated, it is possible to cause melting of the interface between phases. This is called constitutional liquation if, during melting, the bulk composition is in a nonliquid region of the phase diagram but the tie-line between the liquating phases passes through a liquid region. The liquid produced during constitutional liquation can spread along grain boundaries and promote liquid film migration (LFM). This is known as constitutional liquid film migration (CLFM), which is thermodynamically similar to liquid film migration; however, mechanistically there are significant differences. Nickel-base alloy 718 has been studied to show the features of migration that are unique to CLFM. Experimentation consisted of heat-treating rods of alloy 718 to promote the trapping of niobium carbide particles on the grain boundaries. These samples were then subjected to isothermal treatments above their constitutional-liquation temperature, which produced CLFM of the grain boundaries. The movement of the liquid films away from their centers of curvature, the formation of a new solid solution behind the migrated liquid films, and the reversals of curvature of the migrated liquid films confirmed that CLFM was the phenomenon observed. The concentration of niobium behind the migrated liquid films for isothermal treatments below the solidus temperature was shown to be greater than the niobium concentration in the matrix. Above the solidus temperature, there was no increase in niobium concentration. The validity of the coherency strain hypothesis as the driving force for CLFM in alloy 718 is discussed.

Dr. Wayne Chen, DSI Director of Research, Presents Two Papers

Weld Cracking: Basic Problems—Advanced Solutions, Milwaukee, Wisconsin, USA, July 20–21, 2000

New Tests For Welding Cracks

There are over 150 weldability testing techniques to date. In general, they can be classified into two categories as representative (self-restraint) and simulative (augmented restrain) test techniques. The representative test technique usually tells only 'cracking' or 'no-cracking' of a material when an actual welding situation is represented, which cannot quantify the cracking susceptibility of the material under different welding conditions. The simulative test can follow a thermomechanical history of a material during welding, and an external strain is usually applied to be able to quantify the cracking susceptibility, i.e., weld metal solidification cracking susceptibility and HAZ cracking susceptibility. Among the simulative tests, the Varestraint test and the Gleeble hot ductility test are the most widely used in weldability studies.

This presentation will first discuss the solidification cracking susceptibility test and then introduce a new testing procedure in weld metal cracking susceptibilities, i.e., the Strain Induced Crack Opening (SICO™) procedure. To simulate the fusion process in the weld metal zone, a specimen must be heated to its melting temperature. This fusion process can be controlled by Gleeble power input. The solidification cracking susceptibility can be studied simply by fixing the jaws during subsequent solidification to examine if the specimen has cracks, or further cooling to different temperatures to pull the specimen apart to measure the hot ductility.

The SICO procedure was originally developed for hot workability studies of metals. The critical strain defined as the hoop strain at the onset of cracking during compression is measured to characterize the hot workability. The SICO procedure has also been applied to study the solidification cracking susceptibilities. In multi-bead welds of austenitic stainless steels and nickel-base alloys, small cracks (or so-called microfissures) can occur in characteristic sites just below the top layer of the weld. SICO tests can be used to examine the presence of microfissures in multipass welding process simulation. The critical strain obtained from specimens cut from the top layers showed lower values than that at the bottom layer at given temperatures. The difference in the critical strains indicates the presence of the microfissures in the multi-bead welds. Four electrode alloys were examined in this study using the SICO procedure. The testing procedure complies with the proposed micromechanism of the microfissure formation and is considered to be suitable for microfissure susceptibility studies in multipass welds of high alloy stainless steels and Ni-base alloys.

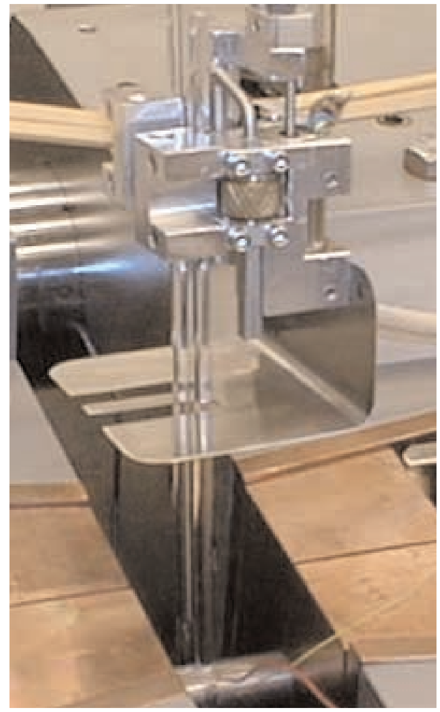
2000 International Conference on Superplasticity in Advanced Materials—ICSAM 2000, Orlando, Florida, USA, August 1–4, 2000

Development of Ultrafine Grained Materials Using the MAXStrain® Technology

by Wayne Chen, David Ferguson, and Hugo Ferguson

Costly processing of fine grain materials and low strain rate superplastic forming has been the bottleneck for development of the superplastic forming technology. It has been realized that the finer the grain size the faster a complex part can be superplastically formed. Several techniques have been developed to produce the ultrafine grain structures primarily using a severe-plastic-deformation method, such as equal channel angular pressing (ECAP), 3D forging, high pressure torsion (HPT), and accumulative roll bonding (ARB). Recently, a multi-axis restraint deformation technique (MAXStrain technology) was developed to achieve extremely large strains. The technology offers the potential to cost-effectively produce industrial-size ultrafine-grained bulk materials, such as aluminum alloys. In this paper, a cost-effective procedure of developing ultrafine-grain structures of a commercial aluminum alloy will be presented. The results show that the MAXStrain technology is promising in industrial applications, such as making materials for high strain rate superplastic forming.

If you would like more information about either of these subjects, contact us at DSI.



New CCT Dilatometer

Continued from Page 1

Standard configuration is 5 mm to 12 mm (0.2 inch to 0.5 inch) diameter.

Resolution

± 0.4 µm (± 0.00001 inch). This resolution is based on the electronic signal conditioning used with Series 3 digital controls.

Transducer Type

LVDT design.

Operating Temperature

Quartz contact tips rated for continuous operation from –18°C to 1300°C (0°F to 2370°F) and limited time operation up to 1400°C (2550°F). Heat shields required at all times. Measuring unit of transducer is rated for operation from –18°C to 150°C (0°F to 300°F). Heat shields are provided for protection of the measuring unit section of the transducer. Unit can be air or helium gas cooled.

The 39018 CCT Dilatometer Kit includes the transducer, heat shield, mounting brackets, calibrated signal conditioner, quartz rods for use with specimen sizes from 5 mm to 12 mm diameter and a carrying case. For additional information about the 39018, contact us at DSI.

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

The Gleeble at the University of Birmingham

Continued from Page 1

(for modeling purposes). A mixture of plane strain and uniaxial compression tests have been performed.

The versatility and control of the Gleeble means that it is now also used in other research projects not associated with net shape production. Some researchers are using the Gleeble to perform heat-affected zone simulations on structural steels that are used in powerplants. They are examining embrittlement during fabrication and operation that can be represented by complex heat treatment cycles. Work is also being carried out to examine the influence of microstructural features on the initiation of cleavage in heat affected zones, for example in titanium containing steels.

Investigators of tool steels are looking at the generation of constitutive equations for modeling the machining process in terms of heat generated, chip formation, and stress/strain relationships at temperature. The materials information generated using the Gleeble will be used to increase the accuracy of the finite element models developed for these steels. Other investigators are working with titanium aluminide alloys, for the aerospace industry, examining the effect of composition on phase stability and transformation behavior.

Dr. Davis speaks with Roderick Smith, manager of the Net Shape Manufacturing Centre where the Gleeble 3500 is located.

The Gleeble strip annealing system has recently been purchased and will be used in a project aimed at developing a practical system to monitor steel transformation behavior in-situ during cooling after hot strip rolling. Measurements made in the Gleeble, using both rod and strip samples, will allow accurate calibration (with respect to microstructural development) and further development of the system. This is a typical example of a multi-disciplinary research project (involving several companies, including Corus—formerly British Steel, and another university) that requires the capacities that the Gleeble offers to be successful.

"The Gleeble allows us to increase the scientific understanding in some of the research projects," Dr. Davis says. Dr. Davis adds, "Because of its thermo-mechanical capabilities and the level of control attainable, the Gleeble allows us to get the precision of processing and accuracy of information that we need."