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The Gleeble® NEWSLETTER

Summer 1998

Gleeble Systems Application Notes

A number of application notes that give the details of performing specialized tests on Gleeble physical simulation systems are now available. The list is below.

These application notes are available without charge. To obtain a note that interests you, please e-mail your request to info@gleeble.com or contact us by phone, fax or mail.

APN001 – Axisymmetric Uniaxial Compression Testing Using ISO-T Anvils on Gleeble Systems

APN002 – Flow Stress Correction in Uniaxial Compression Testing

APN003 – Flow Stress Correction Methods in Plane Strain Compression

APN004 – Linear Strain Rate Controlled Flow Stress Testing

APN005 – Isothermal Quenching (ISO-Q) Technique for Development of CCT/TTT Diagrams Using Gleeble Systems

APN006 – Application of Gleeble Systems in Semi-Solid Processing Simulation

APN007 – Uni-Directional Tension/Compression Test

APN008 – Application of Parallel Heating Technique in Gleeble Systems

APN009 – Simulation of Laser Welding HAZ Using Gleeble Systems

APN010 – Diffusion Effects on Type K (Cr-Al) Thermocouple Measurements

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Gleeble Application Profiles:

The Gleeble at Schweißtechnische Lehr- und Versuchsanstalt Mecklenburg-Vorpommern GmbH

Schweißtechnische Lehr- und Versuchsanstalt M-V GmbH Institute in Rostock, Germany, is responsible for training and education of welders, welding specialists and welding engineers. In addition, the Institute is responsible for quality assurance in structural steel works and for materials testing, as well as research and development.

Research and development at the institute is focused on laser material processing, studies on weldability, and research into the application of computers in welding engineering. A Gleeble 3500 was purchased for a project called "LASER 2000." The aim of this project, which involves more than 25 partners in Germany, is to investigate various aspects of laser welding in depth.

Areas of interest for LASER 2000 include:

- phase transformation during welding and hardening,
- selection of suitable filler material,
- mechanical behavior of laser welds, and
- quality assurance.

For Jan Hoffman, physicist, and his colleagues at the Institute, part of this project is to investigate the transformation behavior of low alloyed and unalloyed

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SLV's laser equipment includes a high-power CO_2 laser (12 kW output power) integrated in a six-axis beam guiding system (4 meters × 1 meter × 0.5 meter). It is able to weld a plate thickness of 15 mm in one pass.

Recent Gleeble Papers

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A Model for Galvanneal Morphology Development

C.E. Jordan and A.R. Marder

Cross-sectional and planar views of galvanneal coatings were studied to characterize morphology development. Cross-sectional analysis of coatings annealed under different time temperature conditions showed the formation of three distinct morphological coating types. The morphology types were classified as Type-0, Type-1, and Type-2, and represent an under alloyed, a marginally alloyed, and an over alloyed coating structure, respectively. The structures were analyzed to quantify the chemistry associated with each morphology. Planar observation of the coatings during annealings was performed in-situ in an environmental SEM. Burst-like structures were found to form during annealing, and the role of bath aluminum content on their formation was studied. From these results a phenomenological model for galvanneal morphology development is proposed.

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Embrittlement of Gun Steel by Copper

by R.M. Fisher and A. Szirmae

Metallographic examination of the bore surfaces of cannon tubes revealed a close association of copper with the erosion and cracking that occurs during firing. Metallic copper, transferred by abrasive contact between the steel surface and the copper rotating band on the projectile that engages the rifling can induce embrittlement and enhance propagation of cracks developed by the thermal-mechanical stresses generated during firing. Corroborative experiments using capacitance discharge heating verified that copper-induced embrittlement and cracking can occur during a thermal pulse of only a few milliseconds duration. Hot tensile testing with a Gleeble machine confirmed that copper penetrates austenite grain boundaries causing hot tearing in just a few seconds at 1000°C, i.e., well below the melting point of copper.

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Zircaloy-4 Oxidation in Steam Under Transient Oxidizing Conditions

by W.G. Dobson, R.R. Biederman, and R.G. Ballinger

Oxidation of Zircaloy-4 in unlimited steam has been studied under conditions simulating a loss of coolant accident (LOCA) using a specimen heating system (Gleeble). Simple linear ramp transients have been analyzed as well as a few postulated LOCA transients for currently operating light water nuclear power plants. Comparison is made between computer code prediction using isothermal oxidation kinetics and experimental observation with regard to the extent of oxidation. Simulation of Zircaloy oxidation assuming a stepwise isothermal model using isothermal kinetics developed by the authors is compared to experimental measurements of the extent of oxidation. This computer code, designated TRANS-1, accounts for prior oxidation present and results in agreement with experimental measurements of oxide and oxygen stabilized α-thicknesses for high heating and slow cooling rate transient profiles. However, as heating rate decreases and cooling rate increases, this model becomes increasingly conservative. Modeling, using either a series-expansion or a slope-based isothermal kinetics model, results in essentially the same prediction as TRANS-1. A one-dimensional finite-difference moving-boundary diffusion model has been developed and found to predict accurately isothermal oxidation behavior of Zircaloy-4 in steam. This model also can be used to predict transient behavior. In addition to predicting oxide and stabilized α thicknesses, this code is capable of predicting oxygen concentration gradients in all phases present, total oxygen as the summation of oxygen present in each phase, and formation of oxygen stabilized α-incursions in the β-phase if accurate diffusion coefficients and appropriate phase equilibrium information are known.

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Predicting the Onset of Transformation Under Noncontinuous Cooling Conditions–Part II: Application to the Austenite Pearlite Transformation

by T.T. Pham, E.B. Hawbolt, and J.K. Brimacombe

A detailed review of the additivity principle with respect to the incubation of the austenite decomposition was summarized in Part I of this two-part series and led to the concept of an "ideal" time-temperature-transformation (TTT) diagram. The curve is characteristic of the chemistry and austenite grain size in the steel and allows nonisothermal behavior to be described assuming additivity holds. The derivation of mathematical relationships between the ideal and experimental cooling data was presented in the first article. In this second article, and ideal curve for the austenite-to-pearlite transformation was derived from cooling data. The applicability of the ideal TTT curve for predicting the start of transformation under continuous cooling conditions was assessed for a range of cooling rates. Experiments were conducted under both isothermal and varying temperature conditions, including an industrial cooling schedule using a Gleeble thermal simulator. Reasonable agreement was found between the predictions and the observed transformation start temperatures; predictions were consistent and compared favorably against other methods which have been frequently used to eliminate the transformation start temperature for non-isothermal conditions.

The Gleeble 3500 at Schweißtechnische Lehr- und Versuchsanstalt Mecklenburg-Vorpommern GmbH

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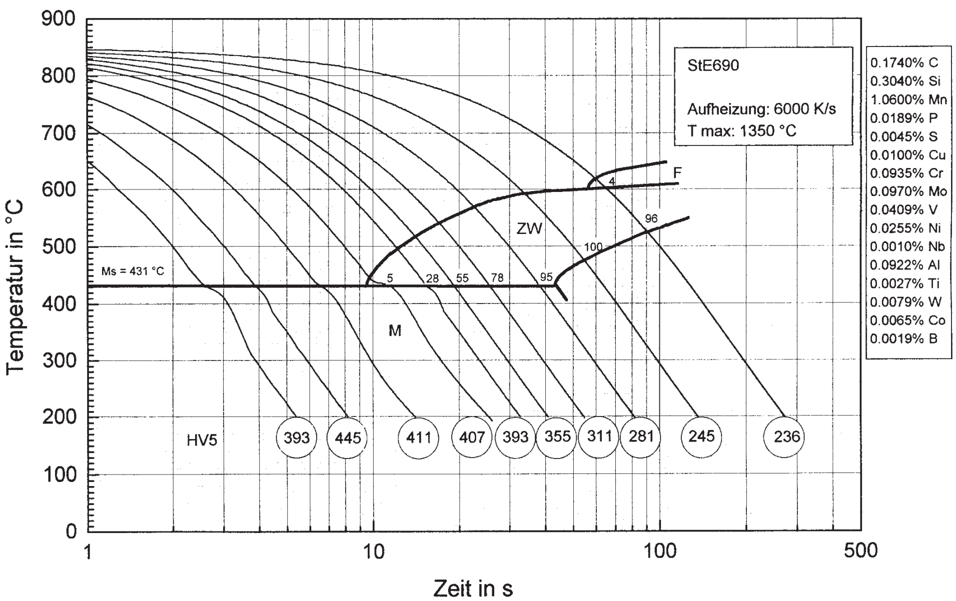
steels during laser beam welding. The goal is to develop 13 time-temperature-transformation (TTT) diagrams, which represent the conditions typical for laser welding. Supplementary diagrams with the mechanical characteristics like tensile strength, hardness, toughness and elongation will also be developed with the help of simulated specimens.

Hoffman says, "The Gleeble is a necessity for our work. During laser welding you get heating rates up to 10,000°C per second. The Gleeble can simulate that. But it's impossible with other machines that use other heating techniques."

Hoffman adds, "The problem with laser welding is that the heat-affected zone is very small—about 1 mm wide. That doesn't give us enough material to investigate the mechanical properties of the laser weld such as hardness and toughness. With the Gleeble, we're able to perform a physical simulation that gives us a specimen with a much larger HAZ. With it, we can perform the tests that we want."



Top: This transformation diagram shows laser welding time-temperature-transformation for high strength structural steel S690Q. Bottom: SLV's Gleeble 3500 system.

At present, the work has been completed for three materials. With the help of the diagrams that are being developed at the Institute, it is now possible for everybody to estimate the properties of the welded seam before executing the actual weld. When the work is finished a manual "Laser Weldability" will be published.

Besides laser weldability, the Institute is also using the Gleeble 3500 for other laser-related research.

"In cooperation with a producer of engines for bulk carriers or container vessels, we are searching for materials with a high wear and corrosion resistant and for suitable technologies, such as laser cladding, for putting thin layers on the surface to protect the surface of those engine parts," Hoffman says.

Typical base materials are heat-treatable and case-hardened steels. Various cobalt-based alloys are being considered as cladding material to protect pistons, valves, and camshafts. Typical tests involve simulating the temperature cycle within a diesel engine: heating to 400°C, then cooling to 200°C and repeating this cycle or a similar cycle multiple times.

Hoffman says, "The Gleeble helps us to predict and investigate the properties of those layers and the fusion zone. Further, we can physically characterize our new materials and then use finite element analysis to calculate the static or dynamic behavior of engine parts."

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Application Notes

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APN011 – Liquation Embrittlement Study Using Gleeble Systems

APN012 – Liquid / Solid Interface Studies

APN013 – Strip Annealing Physical Simulation Including Continuous Annealing Processes

APN014 – Evaluating the High Speed Performance of Servo Hydraulic Systems for Process Simulation and Testing Work—Force vs. Velocity

APN015 – Measuring Phase Transformations in a Sheet or Strip Specimen

APN016 – Transverse Flux Induction Heating Simulation

Gleeble Newsletter

The Gleeble Newsletter is intended to be a forum for Gleeble users worldwide to exchange ideas and information. We welcome your comments and suggestions. Letters, comments, and articles for the newsletter may be addressed to David Ferguson at Dynamic Systems Inc., faxed to us at (518) 283-3160, or e-mailed via the Internet: info@gleeble.com.

Come See Us at the Shows!

Fifth International Conference on Trends in Welding Research
June 1–5, 1998
Pine Mountain, Georgia

Visit us at the Fifth International Conference on Trends in Welding Research to be held June 1–5, 1998, in Pine Mountain, Georgia. DSI Applications Engineers will be available to discuss welding simulations and applications on Gleeble Series 3 systems.

For more information about this meeting, contact:

American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126
Tel (U.S.): (800) 443-9353, ext. 223
(International): (325) 443-9553, ext. 223
Fax: (305) 443-1552

AEROMAT '98
June 15–18, 1998
Washington D.C.

DSI will be exhibiting the latest in Gleeble Systems technology at Booth #18 at AEROMAT '98, to be held at the Sheraton Premiere at Tysons Corner, Washington D.C.

For additional information, contact:

ASM International
9639 Kinsman Road
Materials Park, OH 44073-0002
Tel: (440) 338-5151
Fax: (440) 338-4634
E-mail: mem-serv@po.asm-intl.org

1998 Materials Solutions Conference and Exposition
October 12–15, 1998
Rosemont Convention Center
Rosemont, Illinois

DSI will be exhibiting the latest in Gleeble Systems technology at Booth 101. Applications Engineers will be available to discuss your materials testing and physical simulation requirements.

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