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The Gleeble® NEWSLETTER

Spring 1998

Gleeble Application Profiles:

The Gleeble at Erlangen-Nuremberg University

For researchers in Materials Science and Technology for Metals, Department of Materials Science, Erlangen-Nuremberg University in Erlangen, Germany, the Gleeble has become an essential tool for several areas of investigation. The university has had a Gleeble 1500 since 1994.

Jane Blackford, PhD, Research Associate in the Superalloy Group, is looking at the castability of superalloys, particularly as it relates to directional solidification, which is a common process for making turbine blades.

Dr. Blackford says, "We're trying to discover which compositions allow us to cast superalloy blades without cracking along the grain boundaries."

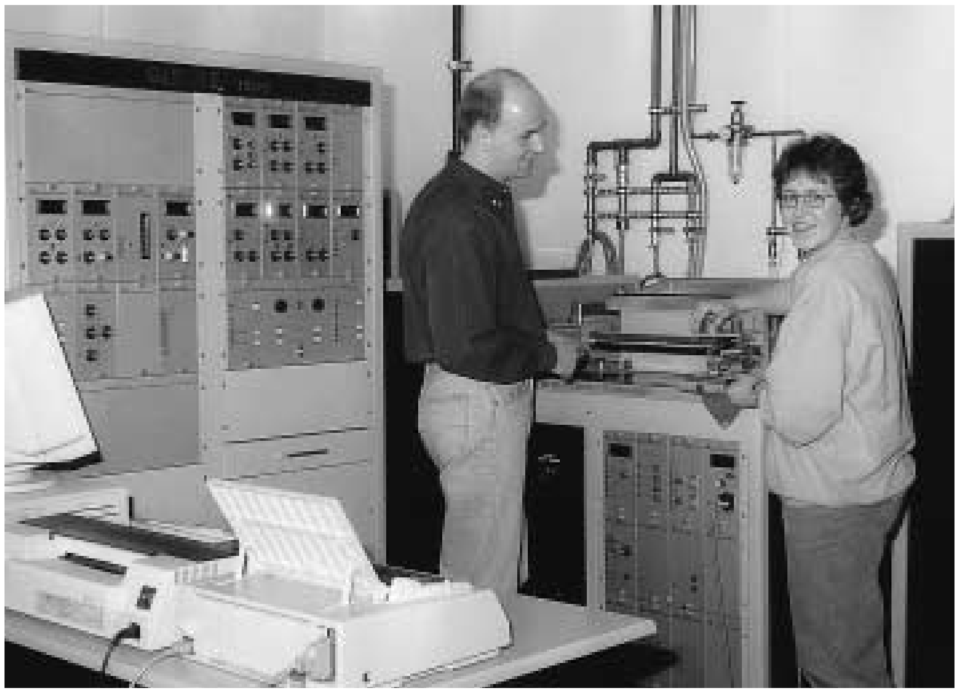
Dr. Blackford has been casting tubes as a substitute for turbine blades, because the relatively simple shape of tubes makes it easier to get reproducible and quantifiable results. These results can then be applied to the more complex shape of the turbine blades.

Another facet of Dr. Blackford's work involves making big plates of directionally solidified materials. Samples are then machined out of the big plate and are subjected to nil strength and nil ductility testing on the Gleeble. The nil strength tests are conducted around 1250°C, and the nil ductility tests about 100–150 degrees below that.

Dr. Blackford says, "We're hoping to use the data from the Gleeble tests as a predictor of composition behavior and casting parameters and as a way of getting more quantifiable thermomechanical data about the structure."

Preliminary results indicate quite a good correlation between a small nil ductility range and good castability. Dr. Blackford says, "In terms of quantifiable results, the Gleeble is the only machine I could use

Continued on Page 4



Hannes Hegels and Jane Blackford use the Gleeble 1500 at Erlangen-Nuremberg University. The Gleeble has become an essential tool in many areas of investigation.

Strip Annealing on the Gleeble 3500

The Gleeble 3500 can be used to simulate the process for the strip annealing of sheet materials. Doing so allows researchers to stimulate innovative thinking, to rapidly fine-tune the strip annealing process, to save considerable money, and to avoid the capital risk associated with experimenting on an expensive production continuous annealing line.

Researchers can accurately replicate the strip annealing process on the Gleeble with very accurate control of the thermal cycle, including heating and cooling rates, as well as hold times. The Gleeble can simulate both full quench and arrested quench processes and allows control of the atmosphere.

Strip annealing simulation on the Gleeble 3500 allows use of the same material and at the same thickness as would be found in the actual production continuous annealing line. The simulation specimen is large enough so that when the experiment is done, there is enough material to do full-size tensile testing to obtain property data, such as *r* value, yield stress, elongation, elastic modulus, and ultimate tensile strength. In addition, when the strip annealing simulation is completed, the microstructure can be analyzed.

To perform strip annealing simulation, the Gleeble 3500 must be equipped with a Model 9505-050 strip annealing jaw

Continued on Page 3

Recent Gleeble Papers

293

Stress Rupture Evaluation of Weldments and Base Metal in a Modified 800H Alloy

C. D. Lundin & C.Y.P Qiao

Stress Rupture evaluations were conducted on a modified 800H alloy. It was shown that the HAZ of the modified 800H exhibited a significantly lower rupture strength than the base metal. It was revealed that the rupture locations were in the HAZs for both Gleeble simulated HAZ and actual weldment samples. Thus, for modified 800H, structural design should be based upon the HAZ mechanical properties rather than that of base metal if welded fabrication is required for application. Modified 800H is one of a series of advanced austenitic alloys developed at Oak Ridge National Laboratory. Modified 800H belongs to 20Cr-30Ni-Fe alloy system. Ti, Nb, and V rich MC type and Cr and Mo rich $M_{23}C_6$ type carbides are the major precipitates which are responsible for the improved high temperature strength contrasted to conventional austenitic stainless steels. In addition, the mechanical properties of modified 800H are significantly related to the thermomechanical treatment during material fabrication. With an optimum thermomechanical treatment, the excellent high-temperature mechanical properties and corrosion resistance were defined as compared to conventional austenitic stainless steels [1]. As was revealed in a previous investigation [2], HAZ softening behavior was evident in the HAZ of modified 800H. Microstructural investigations on weldments of modified 800H [3] manifested that the formation of a “soft” zone was mainly related to precipitate dissolution, grain growth and recrystallization. In other words, HAZ softening is dependent on the HAZ microstructure and HAZ reactions during weld fabrication. Since a thermomechanical treatment was performed during material processing and precipitate strengthening was designed into modified 800H, an HAZ softening phenomenon is a potential in weldments. Therefore, three questions arise: (1) will a decrease in HAZ hardness in modified 800H significantly affect the stress rupture properties of a welded structure? (2) how will the filler material and welding process influence the stress rupture behavior of a weldment in modified 800H? And (3) how can HAZ softening be mitigated in order to extend the application of modified 800H? Short-term stress rupture tests and aging studies were performed order to answer these questions. For the above three questions, a discussion of the second and third questions was covered in previous reports [3,4] and this paper will emphasize work designed on the answer to the first question.

300

Morphology Development in Hot-Dip Galvanneal Coatings

by C.E. Jordan and A.R. Marder

Hot-dip galvanized drawing quality special killed (DQSK) steel and titanium stabilized interstitial free (IF) steel substrates were annealed under varying temperature and time conditions in order to characterize the coating structure development which occurs during the annealing portion of the galvannealing process. Through the use of light optical microscopy, the coating morphology development (Fe-Zn alloy layer growth) observed in cross section on both substrates was defined in three distinct stages. The three characteristic microstructures were classified as type 0 (underalloyed), type 1 (marginally alloyed), and type 2 (overalloyed) morphologies. The morphology transitions were quantitatively defined by total iron content in the coating and by the thickness of an interfacial Fe-Zn gamma phase layer. The DQSK steel coating type 1 to type 2 morphology transition occurred at an iron content of 9 to 10 wt pct. For the titanium IF material, the same type 1 to type 2 morphology transition occurred at an iron content of 10.5 to 11.5 wt pct and at an interfacial layer thickness of approximately 1.0 µm. An increased amount of aluminum in the galvanizing bath delayed the alloying reaction during galvannealing for both substrates. The overall inhibition effect of aluminum was less pronounced on the titanium stabilized IF material, indicating that its coating alloying kinetics were not as significantly influenced by bath aluminum content.

305

Oxidation Reaction Kinetics of Zircaloy-4 in an Unlimited Steam Environment

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

Experimental studies using a Gleeble have been performed on reactor grade Zircaloy-4 tubing to determine the oxidation behavior in steam throughout the 871°C to 1482°C temperature range. Isothermal oxidation under unlimited steam conditions has been found to obey the parabolic oxidation law with a rate constant for total reacted metal of $K_p = 3.10 \times 10^5 \exp(-33,370/RT\,(K))$ $(mg/cm^2)^2/sec$. This measured rate is significantly lower than that predicted by Baker-Just for temperatures above 1077°C and in very good agreement with that suggested by Klepfer for the temperature range where tetragonal zirconium oxide is stable. Oxidation data presented are also in good agreement with those given by Hobson and Rittenhouse for oxidation below 1316°C but significantly less for oxidation above 1316°C. Oxidation of Zircaloy-4 in steam has been observed to be independent of steam superheat temperature and only slightly dependent on steam flow. It is apparent that as long as steam is present and hydrogen can migrate away, oxidation rate is independent of Reynolds number or velocity. Only steam starvation and/or trapped hydrogen appear to lower the rate of oxidation of new Zircaloy cladding.

Strip Annealing on the Gleeble 3500

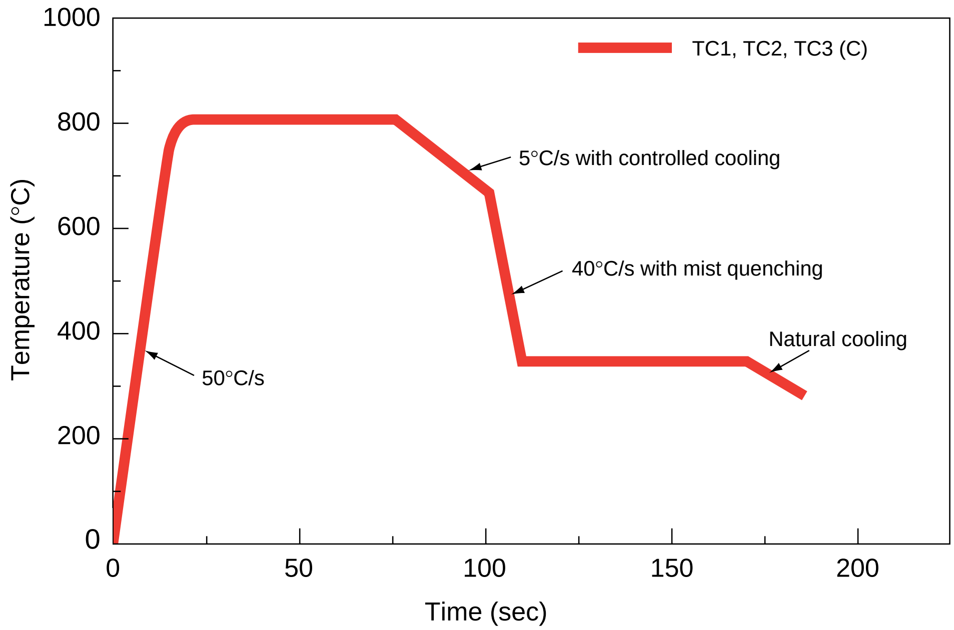
Continued from Page 1

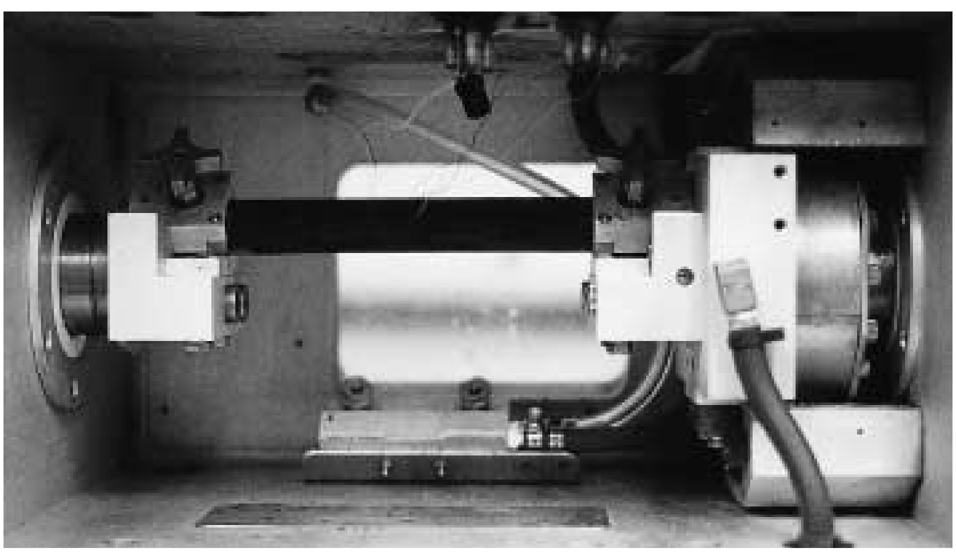
system. In addition, the Model 38515 Atomizing Quench System is also required.

The jaw system provides the means for mounting the specimen in the proper location in relation to the atomizing spray. The quench system provides control of the air pressure, the air-water mixture ratio, and water pressure so that quenching conditions can be controlled and simulated. The quenching system has a multiple valve setup that can allow multiple cooling rates during the same simulation sequence.

The temperature program is controlled by the Gleeble 3500 computer which also acquires all the data from the annealing simulation. Multiple thermocouples can be welded to the specimen, if desired, to measure and verify the uniform temperature zones. A complete instruction set and examples of sample programs are provided with the jaw set and quench system. The recommended specimen size is 50 mm wide × 200 mm free span, although certain other sizes can be used.

At present, a number of international steel producers are using the strip annealing simulation with great success. For additional information about strip annealing on the Gleeble 3500, contact us here at DSI.





Top: A typical arrested quench thermal cycle with controlled cooling rates.
Bottom: A strip annealing jaw set is installed in a Gleeble 3500 system atmosphere tank.

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:

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Erlangen-Nuremberg University's Web site can be found at www.uni-erlangen.de

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) 283-1360, or e-mailed via the Internet: info@gleeble.com.

The Gleeble at Erlangen-Nuremberg University

Continued from Page 1

because of its rapid heating rate. We're measuring what happens when everything is semi solid—with a conventional heating system, you would not get anything near to what we hoped to simulate."

Hannes Hagels, Research Associate in the Powder Metallurgy Group, and his colleague Peter Randelzhofer, is working on the development of chrome-based alloys, and the Gleeble is an essential part of their work.

First, the powder alloy is consolidated to full density through Hot Isostatic Pressing (HIP). Then samples of the fully dense alloy are placed on the Gleeble for rolling simulations—a series of plane-strain compressions at about 1300°C.

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These alloys show excellent performance at high temperature, superior corrosion resistant, and excellent hardness and wear resistance. The goal of this research program is to develop both compositions and processing maps for chrome alloys that could be used in high temperature structural applications such as heat exchanger tubes and high temperature fuel cells. The Gleeble facilitates the work since it is really easy to achieve a lot of different testing parameters on the system.

Thomas Grogler and his colleagues in the Diamond Coating Group is experimenting with putting down layers of diamond for wear and corrosion resistance on Ti-6Al-4V alloys. These materials have applications in drill bits, artificial hip joints and even golf clubs.

The diamond is deposited on the alloy in a huge vacuum chamber. The Gleeble is then used to test the properties of the substrate after it has been coated. Typical Gleeble tests involve tension testing at 500°C. The researchers want to determine if hydrogen has defused into the material below the coating and if the substrate has been weakened by hydrogen embrittlement. The ultimate goal of this research effort is to evaluate various coating techniques and post-coating heat treatment schedules.

Finally, the Gleeble at Erlangen-Nuremberg is used for continuing a research project that was begun there and has since moved to Bayreuth University, which is in the process of acquiring its own Gleeble.

In the words of one researcher, "If you're going to do laser welding research, you've got to have a Gleeble or you're not in the game."