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The Gleeble® NEWSLETTER

Summer 1997

ISO-Q™ Technique Allows CCT Work with High Cooling Rates

When you want to make CCT or other types of isothermal measurements and have high cooling rates — that is, above 100°C/sec., a problem arises. You need to come up with a way to cool the specimen quickly while preserving the isothermal plane in the middle of the specimen.

The new ISO-Q fixture available from DSI does just that through the use of holes drilled into each end of the specimen. High pressure cold water is forced to the inner end of the holes, extracting heat from the ends of the work zone of the specimen, providing the necessary rate of cooling, and preserving the isothermal plane at the midpoint of the specimen. With this fixture, cooling rates of as high as 400°C/second have been achieved.

In addition, this fixture is completely self-contained so none of the cooling water is sprayed about in the tank. As a result, this work can be done in a vacuum or inert gas. This also permits the use of either the laser or contact dilatometers, and dynamic CCT after deformation can even be performed.

When even higher cooling rates are required, a hole can be drilled through the length of the specimen, creating a thin-wall tube. Water is forced through the tube to produce cooling rates of more than 2,000°C/second. This technique does not preserve the isothermal

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Gleeble Application Profiles:

IPSCO Solves Hot Shortness Problem

by Dr. Milos Kostic, IPSCO, Inc.

At IPSCO, Inc. of Regina, Saskatchewan, we make a steady quantity of high carbon steels (similar to AISI 1075 and 1085) as hot rolled coils. The product is used to make heat-treated, abrasion-resistant parts for agricultural equipment such as plows and cultivators.

IPSCO's process, which includes melting of scrap in an electric arc furnace and continuous casting, makes the surface quality sensitive of the products to process variables during slab reheating and early stages of rolling.

A year ago, during a period lasting several months, we experienced unacceptably high losses during processing. The problem manifested itself as hot shortness (lack of hot ductility) in the initial reduction passes. The result was transverse cracking of the pieces and ultimately severe surface defects.

We suspected that our reheat temperatures were not optimized. Most of our products require relatively high reheat temperatures of approximately 1,300°C, and with the ongoing product mix, it is inconvenient to use different temperatures for a specific product.

We decided that a simulation of slab reheating and hot rolling in a Gleeble

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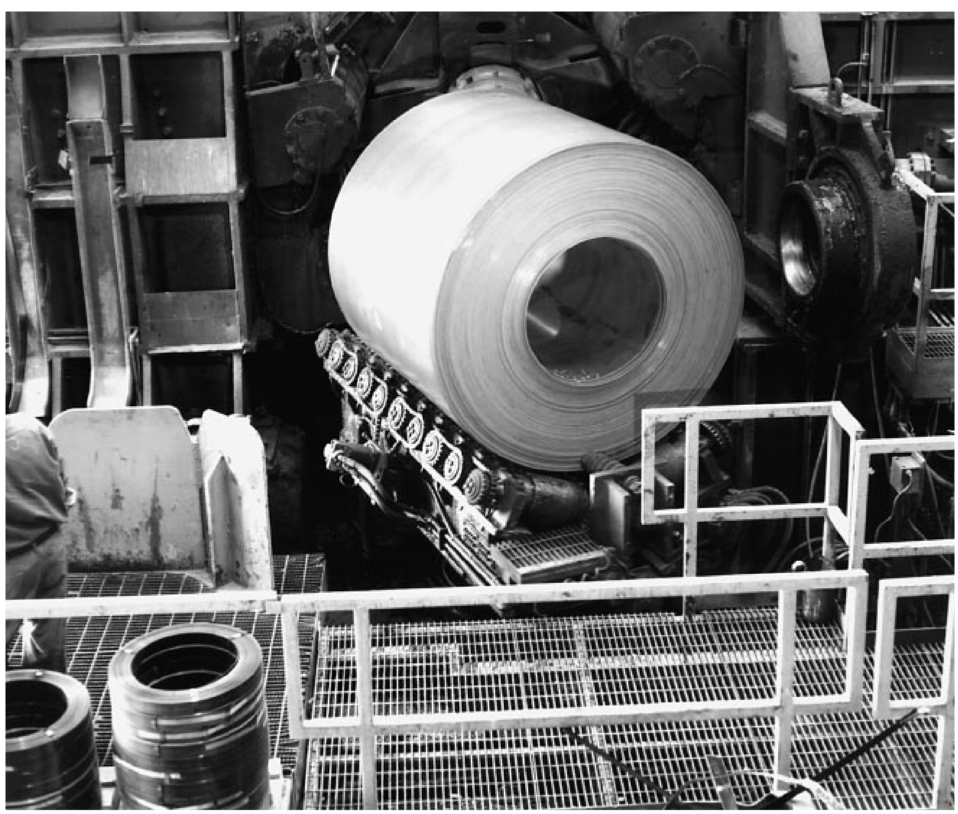

A coil of high carbon steel appears here at the end of the hot rolling process.

Recent Gleeble Papers

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Castability Maps: How to Design the Processing of a Multi-Component Alloy from a Knowledge of the Semi-Solid Morphology and Properties

by J.A. Sekhar, C.S. Lin, and C.J. Cheng

A castability map concept is explored in this paper to predict the optimum conditions of solidification processing (and thus the process) for the manufacture of a given alloy part. It is shown that this involves a knowledge of the mushy zone properties. A multi-component Nickel-Aluminide alloy is considered as the test case for the maps. A complex shaped cast turbo-charger is examined as the case study for the use of the castability map. It is shown that a part of the turbo-charger is solidified in a region of the castability map where micro-cracks may be elongated, thus leading to an unacceptable fatigue life.

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Grain Size Control in Ring-Rolled Alloy 718

by D.R. Nielsen, S.W. Thompson, C.J. Van Tyne, and M.C. Mataya

The controllable independent variables for the processing of ring-rolled alloy 718 were invertigated to determine which were influential in affecting the final microstructure. A Taguchi technique for experimental design was employed to determine the critical independent variables. The variables investigated included: deformation temperature, hold time at temperature prior to deformation, cooling during deformation, cooling after deformation, number of deformation passes, total reduction, strain rate, and initial grain size. From an analysis of variance (ANOVA), the influence of each independent variable on the final microstructure and properties was determined. The measured response variables were percent recrystallization, recrystallized grain size, room-temperature hardness, and high-temperature flow stress. Results of the study revealed that deformation temperature and total reduction were the critical variables in determining percent recrystallization. Recrystallized grain size was dependent on deformation termperature and cooling during deformation, which together detemine the finishing temperature. Cooling rate after deformation was the dominant variable affecting hardness. Temperature and strain rate were the critical variables affecting flow stress.

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Hot Ductility and Hot Cracking Behavior of Modified 316 Stainless Steels Designed for High-Temperature Service

by C.D. Lundin, C.Y.P. Qiao, T.P.S. Gill, and G.M. Goodwin

Test results on modified 316 stainless steels correlated well with those on conventional 316 materials and fully austenitic 316 stainless steels. The weldability of the modified 316 stainless steel was evaluated by the Gleeble hot ductility test and two hot cracking test methods (Varestraint and Sigmajig). The fusion zone and weld metal heat-affected zone (HAZ) hot cracking susceptibilities of the modified 316 stainless steel are similar to conventional fully austenitic 316 stainless steels and greater than the conventional 316 materials that have a primary ferritic solidification mode. The Gleeble hot ductility test results correlate with the base metal HAZ hot cracking results from the Varestraint test and indicate that the modified 316 materials show a considerably higher base metal HAZ hot cracking susceptibility as contrasted to nuclear grade 316 stainless steels. Varestraint test results and Sigmajig test results for the tested materials showed good correlations. The sensitivity of the base metal to HAZ liquation cracking has been successfully predicted by using a newly developed hot ductility criterion, the ratio of ductility recovery (RDR). An excellent correlation between the Gleeble Test criterion RDR and the Varestraint Test criteria (TCL, MCL and CHL) has been found.

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Galvannealing of Interstitial-Free Sheet Steels Strengthened by Manganese, Silicon, or Phosphorous: An Initial Study

by C. Coffin and S.W. Thompson

The effects of various substrate-strengthening additions on the galvannealing behavior at 500°C of hot-dipped, zinc-coated niobium/titanium-stabilized steels were investigated. A base steel containing low levels of alloying elements was studied in addition to similar steels containing significant alloying additions of manganese (0.80 wt. pct.), silicon (0.50 wt. pct.), or phosphorous (0.037 and 0.070 wt. pct.) plus boron. Galvannealing was simulated with a Gleeble thermomechanical test unit. The hot-dipped coatings were observed to react most quickly for the base steel, whereas the alloying rate appears to have decreased slightly for the steels containing substantial amounts of silicon and manganese. Two steels containing significant amounts of phosphorous with boron were associated with the slowest rates of iron-zinc intermetallic phase formation. Examination of coating surfaces revealed the presence of hills, which developed during galvannealing. These hills were related to outbursting, and phosphorous caused a noticeable decrease in the incidence of hills on coating surfaces.

DSI Opens Contract Research and Testing Service

Because many companies would like to have the materials-characterizing, process-optimizing results of Gleeble tests but would prefer that someone else does the testing, contract research and testing services are now available from DSI.

Since DSI is the developer and manufacturer of Gleeble systems, we can draw on 40 years of experience to provide state-of-the-art advice on how and what to test and even develop new technologies and methods to meet the demands of new materials and processes.

Testing is performed on the latest Series 3 Gleeble systems. All equipment is calibrated to NIST standards, and all tests are performed in accordance with best physical simulation techniques and practices.

Contract research and testing is available in the following areas:

Process simulation and research into process parameter setup and operation

Continuous Casting
Hot Rolling
Continuous Strip Annealing
Forging
Heat Treatment
Powder Metallurgy
Sintering
Extrusion
Weld HAZ
Upset Butt Welding
Diffusion Bonding
Hot Deformation

Testing

Thermal Fatigue
Thermal/Mechanical Fatigue
Stress vs. Strain
Hot Ductility
Nil Strength
Creep/Stress Rupture
Continuous Cooling Transformation
Continuous Heating Transformation
Isothermal Transformation

Basic Materials Studies

Diffusion
Stress Relaxation
Melting and Controlled Solidification
Recrystallization
Work Hardening
Hot Cracking
Precipitation Hardening
Constitutional Liquation

DSI contract research and testing services are available on a fixed fee or time and materials basis. For additional information, contact Dr. Wayne Chen by calling 518-283-5350 or e-mail chen@gleeble.com.

New Hot Zone L-Strain Transducer

A new Hot Zone L-Strain transducer is now available for use on Gleeble systems. The new transducer package provides precise measurement of lengthwise strain in the hot zone of the specimen.

The LVDT measurement transducer rides on linear bearing slides for minimum friction and features adjustable spring tension for the alumina rods which contact the specimen. The use of removable setup pins provides easy, precise and repeatable transducer setup for each test. Mounting is available for use on Gleeble 1500, 2000, 3500, and 3800 systems.

A calibrated signal conditioner is provided with the transducer. For additional information, please contact us.

Transducer Specifications

Linear Range	25 mm
Linearity	±0.25% of full scale (25 mm)
Resolution	±2.0 μm
Initial Gage Length	10 mm or 25 mm (user-selectable)
Type	LVDT
Maximum Specimen Temperature	1350˚C
Maximum Stroke Rate	100 mm/second

ISO-Q™ Technique

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plane at the midpoint of the specimen, but the wall is so thin that the effects are generally not detrimental. This technique does not permit compression to be performed.

For additional information about either of these techniques, please contact us.

Materials Week '97 & Materials Exposition

DSI at Materials Expo

You can visit us at the ASM/TMS Materials Expo '97, booth 2101, to be held September 16–18, 1997, at the Indiana Convention Center & RCA Dome, Indianapolis, Indiana.

For additional information, contact DSI or phone ASM International (216) 338-5151, fax (216) 338-4634.

The Complete METALS & MATERIALS Xperience™

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Visit www.gleeble.com

If you'd like more information about Gleeble systems, visit our World Wide Web page at http://www.gleeble.com.

There you will find a wealth of information, including:

- Information on the latest Gleeble systems,
- Press releases issued by DSI,
- Technical articles,
- Upcoming materials-related events,
- A complete collection of Gleeble Application Profiles,
- Contract testing and research available from DSI,
- A brief history of DSI, and
- Links to other interesting Web sites.

Our site is updated frequently, so be sure to visit often!

The Gleeble at IPSCO Steel

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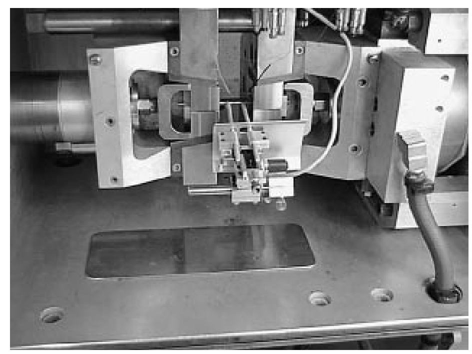
would be the fastest and cheapest way to find the optimum reheat temperature, which should be low enough to avoid hot shortness and high enough to prevent overloading of the mill. We suspected that the interdendritic segregates in the slabs were the preferential sites for disbonding (hot shortness). For this reason, the samples were taken from the as-cast slabs.

The Gleeble testing procedure followed the recommendations of R.E. Bailey et al (Hot Tension Testing, Chapter 5 in *Workability Testing Techniques*, Ed. George E. Dieter, ASM 1984.) An initial series of "on heating" tests were done to determine the temperature region which should be investigated in detail by the "on cooling" tests. The on cooling tests used specimens that were heat treated to simulate slab reheating at different temperatures and then quenched to retain the prior austenite grain size.

The specimens were machined to Gleeble dimensions, reheated to the same "slab reheating" temperature, held briefly at that temperature, cooled to a lower temperature and tested to determine the reduction in area as a measure of its hot ductility. In this fashion, hot ductility curves (R.A. % versus deformation temperature) were obtained for several reheat temperatures.

As a rule, ductility curves display intervals of optimum deformation temperatures. It is then possible to choose a combination of reheat temperature and deformation temperature that promises the highest ductility without an undue increase in flow stress.

The testing program on a Gleeble 2000 at CANMET quickly showed us what the best procedure would be in our instance. After a suitable modification of our processing procedures, the incidence of hot shortness dropped to near zero. We saved hundreds of thousands of dollars with tests costing mere thousands.



A Model 39060 Hot Zone L-Strain transducer is installed on a Gleeble 3500 system.

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.