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The Gleeble® NEWSLETTER

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New Wrapping Technique Solves Thermocouple Attachment for Difficult Alloys

Some materials, such as copper, present a challenge when it comes to attaching the thermocouple wires needed for testing on a Gleeble system. Either you can't weld the thermocouple wires to the specimen or the welds break easily once they are welded.

A recently developed technique allows measurement of the temperature of a specimen using a thermocouple without welding the thermocouple wire to the specimen.

A pair of thermocouple wires is welded together at one end, and then each wire wrapped around the specimen. A two-hole ceramic thermocouple tube slides over the two thermocouple wires and is used to squeeze the wires against the specimen surface. For this technique to work properly, each wire must be in contact with at least half the circumference of the specimen.

The two thermocouple lead wires are then wrapped one turn around an elastic band that is connected to supports on each side of the jaws. The elastic band applies a tension on the thermocouples so that they maintain contact, even during the reduction in diameter that occurs during a tensile test.

An application note describing this thermocouple wrapping technique in full is available. To receive your copy, request APN017.

Gleeble Application Profiles:

The Gleeble at Avesta Sheffield

Avesta Sheffield AB is one of the world's leading producers of stainless steel products. The company makes 41 different grades of specialty stainless steel, and new steels are constantly under development.

Avesta Sheffield purchased a Gleeble 3500 just over a year ago. Since then, the Gleeble has become an essential part of the company's operations. The Gleeble helps Avesta boost productivity, increase quality, and assist customers in using the company's products.

"We do just about everything that a Gleeble is intended to do," says Dr. Ravi Vishnu, Research Engineer in Avesta Sheffield's research department. "We use the Gleeble to simulate hot rolling, heat treatment, welding, continuous casting, and more."

Dr. Vishnu and his colleagues are interested in process optimization for very special grades of stainless steel, and each of these materials has its own idiosyncrasies. As a result, they need to characterize each of these new materials and to discover how to optimize the processing for them.

Avesta Sheffield is the world's largest producer of duplex stainless steel. Heat treatment is a critical operation for the duplex grades and has to be controlled closely to optimize the microstructure. The Gleeble is being used to fine tune the

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The Gleeble makes it possible to optimize the rolling sequence for special grades of stainless steel at Avesta Sheffield's Steckel mill.

Recent Gleeble Papers

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Strain Induced Precipitation at High Temperature in (Nb, B) Microalloyed Steel

by Yang Shanwu, He Xinlai, Chen Mengzhe, Dang Zijiu, and Ko Jun

Stress relaxation tests were employed over the temperature range 800–950°C to investigate strain induced precipitation in an ultra-low carbon microalloyed steel after prestrained about 20%. The observation of samples relaxed different time by TEM suggests that strain induced precipitates nucleate only along dislocations and cause the dislocation movement to be hindered, but once the dislocations escape from the precipitates, these moving dislocations may provide new sites for further precipitations to nucleate. (Paper in Chinese.)

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Modeling Microstructural Development During the Forging of Waspaloy

by Gangshu Shen, S.L. Semiatin, and Rajiv Shivpuri

A model for predicting the evolution of microstructure in Waspaloy during thermomechanical processing was developed in terms of dynamic recrystallization (DRX), metadynamic recrystallization, and grain growth phenomena. Three sets of experiments were conducted to develop the model: (1) preheating tests to model grain growth prior to hot deformation; (2) compression tests in a Gleeble testing machine with different deformation and cooling conditions to model DRX, metadynamic recrystallization, and short-time grain growth during the post deformation dwell period and cooling; and (3) pancake and closed die forging tests conducted in a manufacturing environment to verify and refine the model. The microstructural model was combined with finite element modeling (FEM) to predict microstructure development during forging of Waspaloy. Model predictions showed good agreement with microstructures obtained in actual isothermal and hammer forgings carried out at a forging shop.

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Development of 40 to 50 kg/mm² Tensile Strength, Highly Formable Cold-Rolled Low Carbon Steel by $\alpha + \gamma$ Phase Annealing

by Z. Yao and B.K. Zuidema

The effects of key alloy and process parameters on the mechanical properties of high strength, highly formable low carbon sheet steels have been determined by a combination of laboratory processing, Taguchi Design of Experiments method, and multiple linear regression analysis. Factors studied include C, Mn, P, hot mill coiling temperature, inline annealing temperature, and annealing line speed. Tensile strength levels were varied from 40 to 50 kg/mm² with elongation of 30 to 40%. Annealing conditions were varied from partial to full recrystallization in both the single and $\alpha + \gamma$ two phase region. Effects of the chemistry and process parameters on the mechanical properties will be discussed, with particular emphasis on conditions required to produce a hot dipped galvannealed product meeting 45 kg/mm² tensile strength and 35% elongation minimum requirements.

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Semi-Solid Deformation in Multi-Component Nickel Aluminide—Part I: Equiaxed Alloys

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

A systematic study was carried out to determine the solidification and tensile behavior of semi-solid multi-component nickel aluminide. Controlled equiaxed-solidified samples were tested at various temperatures in the mushy (semi-solid) region. A special Gleeble testing procedure was developed where the samples were quickly raised to a predetermined temperature in the semi-solid zone and fractured. The fracture stress was noted to decrease monotonically with temperature. The strain to fracture exhibited a ductility minimum at an intermediate temperature in the semi-solid zone. For the equiaxed-solidified samples, the fracture stress was found to decrease with increasing cooling rate at any given temperature. At the temperature corresponding to the strain minimum, residual microcracks were detected on the fracture surface. The upper hot-tearing temperature was found to be a function of the solidification variables. The amount of strain accommodation and the hot tearing resistance was found to be a function of solidification microstructure. A fracture map, which is the fracture stress, temperature and cooling rate (σ_f-T-$\dot{T}$) diagram for the equiaxed microstructures, is presented and a castability map is created from the fracture data.

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Physical Simulation of Thermal Mechanical Metal-Working Processes

by E.B. Damm and C.J. Van Tyne

Physical simulation of metal-working processes provides the information that is necessary to make changes that can improve product quality or reduce the time to market with new products or processes. Physical simulation data can provide a link between materials, processes, and models. This paper presents several methodologies used in physical simulation studies and the results obtained from these studies. Among the topics included are improving the thermal mechanical processing conditions of continuously cast slabs to increase yield, reducing the time to market with a new material and process by creating a processing map, troubleshooting internal hot cracking of a forged material, and developing microstructure maps as a function of processing conditions for forged materials.

The Gleeble at Avesta Sheffield

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heat treatment process for duplex grades being produced in a roller hearth furnace recently installed in one of the production units.

In another application, the Gleeble was used to plan for a new production line for heat treatment of longitudinally welded tubes of super duplex stainless steel. Avesta wanted to evaluate two different process routes—bright and quench annealing, but they did not have the equipment in place to evaluate the latter. So they used the Gleeble to simulate quench and bright annealing treatments and subsequently carried out corrosion tests on the simulated specimens to compare the effects of the two alternative processes.

In addition, they have studied the effects of residual elements on the hot ductility of some steel grades during solidification. Gleeble simulation is also being used to see if it is possible to optimize the rolling pass schedule of Avesta's high alloyed super austenitic stainless steel grades.

At Avesta Sheffield, almost all production is done through continuous casting. But some of the grades are developed in small lots through ingot casting. As a result, sometimes problems surface when switching from ingot to continuous casting. The Gleeble has proved invaluable in helping to make the changeover with speed and efficiency.

Another area of investigation for the research group is welding. Welds can be the weakest links in the finished products produced by Avesta's customers. "They want to know that, if they use one of our new steels, they will be able to deliver a product with the qualities that their customers want. The Gleeble allows us to characterize the weldability of a new steel and give weldability information to the companies that buy our steel," Dr. Vishnu says.

The Gleeble's versatility and ease of use are critical to the work done at Avesta Sheffield. They deal with a number of processes, and the Gleeble can be used to investigate, characterize, or improve each one of them. Previously, they used a hot tensile testing machine to perform some of this work, but the Gleeble has far more capabilities.

Dr. Vishnu concludes, "We're constantly finding new things we can do with the Gleeble."

Dr. Ravi Vishnu (seated) with colleagues Frederic Hansen (center) and Kent Karlsson attend the Gleeble 3500 in Avesta Sheffield's research department.

Come See Us at the Shows!

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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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.

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New Product Update

New CCT Dilatometer Kit

The Model 39016 CCT Dilatometer kit is more sensitive, more reliable, and easier to set up than previous models. This strain gage-based dilatometer offers full-scale travel of ± 0.75 mm (± 0.030 inch) and resolution of ± 0.4 µm (± 0.00001 inch). It can handle specimen sizes from 4.5 mm to 12.0 mm diameter (0.18 inch to 0.50 inch diameter). The complete kit includes the CCT dilatometer fixture, 6 mm diameter quartz rods, carrying case, calibrated signal conditioner and other necessary hardware and supplies.

Left: Model 39016 CCT Dilatometer kit. Top: The 39070/39071/39072 Hot Zone L-Strain systems.

Strain Gage Hot Zone L-Strain Systems

The 39070/39071/39072 Hot Zone L-Strain systems are full-bridged strain gage transducers designed to measure lengthwise strain in specimens from room temperature to the temperature at which the specimen become ductile. They can be used to measure 0.2% offset yield and properties of the specimen in the elastic region. Model 39070 offers a gage length of 1.0 inch and travel of 0.5 inch tension, 0.2 inch compression. Model 39071 offers a gage length of 10 mm (0.39 inch) and travel of 5 mm tension, 2 mm compression. Model 39072 offers a gage length of 25 mm and travel of 12.5 mm tension, 5 mm compression. All three models offer resolution of ± 2.0 µm (0.00008 inch) and include a calibrated signal conditioner.

LVDT Hot Zone L-Strain System

The Model 39060 Hot Zone L-Strain System, based on an LVDT transducer, is designed for measuring specimen properties after the specimen becomes ductile. It offers 25.4 mm (1.0 inch) or 10 mm (0.39 inch) gage length, 25.4 mm (1.0 inch) full scale travel, and resolution of ± 2.0 µm (0.00008 inch). A calibrated signal conditioner is included.

For additional information about any of these products, please contact the Sales Department here at DSI.