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The Gleeble® NEWSLETTER

Summer 2002

Come See Us at the Shows

44th Mechanical Working and Steel Processing Conference & 8th International Rolling Conference—Renaissance Orlando Resort, Orlando, FL, September 8–11, 2002

This will mark the first time the International Rolling Conference will be held in North America. The conference will also feature a symposium on zinc-coated steels (processing, structure and properties). General technical sessions will include roll technology, flat roll products, product physical metallurgy and long products and forgings. For further specialization and education, two short courses, one focusing on ultra-low carbon steels and one pertaining to tool steels, are also available. This conference will provide an opportunity for you to exchange ideas with your colleagues and be exposed to state-of-the-art steel rolling technology.

Make it a point to stop by Booth 200. DSI application engineers will be standing by to answer your questions.

For additional information about the conference, contact:

The Iron & Steel Society
186 Thorn Hill Road
Warrendale, PA 15086
Tel: 724-776-1535
Fax: 724-776-0430
Web: www.iss.org

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Gleeble Application Profile

The Gleeble at the Steel Authority of India, Ltd.

Prepared by Dr. S.K. Chaudhuri and Dr. Vinod Kumar.

The Steel Authority of India, Limited (SAIL), the largest steel producer in the country, is a public sector undertaking which produces about 10 million tons of saleable steel annually. Under SAIL, four major integrated steel plants are engaged in the production of bulk product mix in both generic and specialty grades, while three other smaller units are exclusively dedicated to the production of alloy and stainless steel products. SAIL also owns a number of captive mines, for iron ore, limestone and dolomite, as sources of raw materials for steel making. Besides these, it has a stake in two subsidiaries producing ferroalloys and steel products.

The globalization of the steel market in India has meant both challenges and opportunities for SAIL. The challenges are that SAIL must now compete with other steel producers to remain a leader in the market. SAIL's immediate concerns therefore are to match world-class quality at a competitive price. It is in this context that RDCIS, the corporate research unit of SAIL, has been actively involved in

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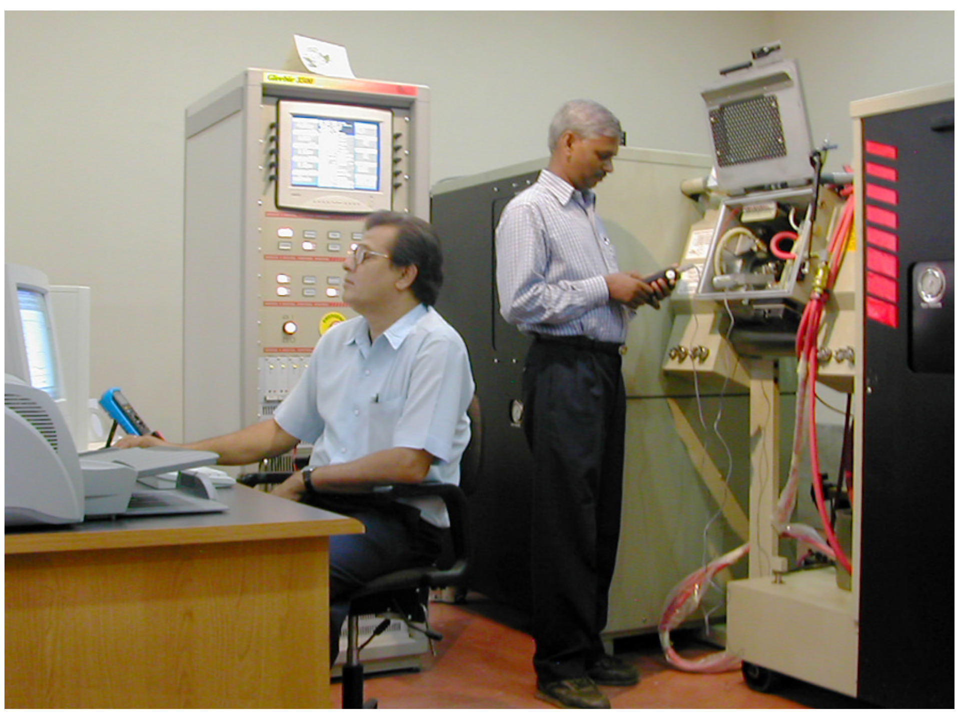

K.K. Mallik, Assistant General Manager, Laboratory Services Group (seated), and Dr. Vinod Kumar, Principal Research Manager, Steel Products Group, carry out load cell calibration tests on the Gleeble 3500C.

Recent Gleeble Papers

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Mechanical Method Determining Precipitation in an Ultra-Low Carbon Bainitic Steel

by Z. Dang, Y. Zhang, J. Ke, X. He, and S. Yang

Stress relaxation was chosen as the best method for monitoring the precipitation process. Tests were carried out on an ultra-low carbon bainitic steel containing Mn, Nb, and B over 800–950°C. Specimens were solution treated at 1250°C for a certain holding period. A prestrain of 20% was applied at a strain rate of 0.1/s. The experimental results are displayed by a set of stress vs. lg (time) curves different from the typical stress relaxation curves. There are two singularities forming a stress plateau on the stress vs. lg (time) curves when precipitates could be observed. Suppose the first one is the start of precipitation (P_s), and the second represents the finish (P_f). As a result, Precipitation-Time-Temperature relationship is described as C-shape curves based on two points. This mechanical method is suitable and precise for measuring precipitates in micro-alloyed steels during hot working.

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Mathematical Modeling of the Extrusion of 6061/Al_2O_3/20*p* Composite

by W.C. Chen, C.H.J. Davies, I.V. Samarasekera, J.K. Brimacombe, and E.B. Hawbolt

An integrated approach, involving laboratory experiments, extrusion plant trials, and finite element modeling (FEM) has been adopted for the study of the extrusion of the metal matrix composite (MMC) 6061/Al_2O_3/20*p*. Gleeble compression tests were performed to develop the constitutive equation of the MMC under industrial extrusion process conditions. Extrusion plant trials were conducted to measure load and temperature and to obtain samples for microstructural analysis. Metal flow, with respect to particle behavior in the deformation zone, was examined microscopically. An FEM based on the commercial code DEFORM was adopted for the simulation of the extrusion of the MMC; the constitutive equation developed was incorporated into the model. Using an updated Lagrangian formulation, both the transient and steady-state regions of extrusion were modeled. Load and temperature predictions resulting from this model agree well with the measured values in the upsetting stage and in the steady-state region. Temperature predictions agree to within less than 3% of the measured values. The FEM predictions of temperature, stress, strain, and strain-rate distribution were correlated with the particle behavior and low-speed cracking during extrusion: large shear deformation promotes particle fracture in the deformation zone, and tensile stress generation in the die land zone of the billet leads to low-speed cracking of the MMC during extrusion. The latter occurs at low temperature in the front end of the billet at the beginning of the extrusion process due to heat loss to the cold die.

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The Solidification and Welding Metallurgy of Galling-Resistant Stainless Steels

by C.V. Robino, J.R. Michael, and M.C. Maguire

The autogenous welding behavior of two commercial galling-resistant austenitic stainless steels, Nitronic 60 and Gall-Tough, was evaluated and compared. The solidification behavior and fusion zone hot-cracking tendency of the alloys was evaluated by using differential thermal analysis, Varestraint testing, and laser spot-welding trials. Gleeble thermal cycle simulations were used to assess the hot ductility of the alloys during both on-heating and on-cooling portions of weld thermal cycles. Solidification microstructures were characterized by light optical and electron microscopy, and the solidification modes and phases were identified. Gas tungsten arc (GTA) welds in both alloys solidified by the ferritic-austenitic mode and their behavior was best described using chromium and nickel equivalents developed specifically for the Nitronic series of alloys. Both alloys were found to be somewhat more susceptible to solidification. Hot cracking resistance of Nitronic 60 was somewhat superior to Gall-Tough. Laser spot-welding trials resulted in both fusion and heat-affected zone cracking in the Nitronic 60, while Gall-Tough was resistant to cracking in these high-solidification-rate welds. Comparison of the laser weld microstructures indicated that Nitronic 60 shifts to fully austenitic solidification, while Gall-Tough shifts to an austenitic-ferritic solidification mode in high-energy-density processing. The hot ductility measurements indicated that Gall-Tough is generally superior to Nitronic 60 in both on-heating and on-cooling tests, apparently as a result of difference in grain size and the mechanism of ferrite formation at high temperatures.

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The Structural Evolution of Superalloy Ingots During Hot Working

by R.M.F. Jones and L.A. Jackman

This article provides an overview of structural changes that occur during the hot working of superalloys and provides insight into the use of precipitated particles and other thermomechanical factors to achieve desired structures. Examples will focus primarily on alloys 718 and 720, which are iron-nickel and nickel-based alloys, respectively. The availability of second phase to control grain size is a characteristic of some iron-nickel and nickel-based superalloys that is not usually available to cobalt-based superalloys; processing with and without the use of a precipitated phase that influences microstructures will be illustrated by the use of these examples.

The Gleeble at the Steel Authority of India, Ltd.

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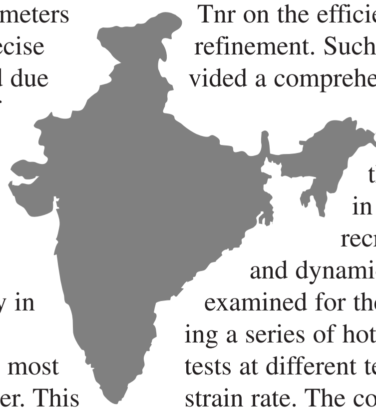
upgrading its existing processing technologies and assimilating new technologies introduced during modernization of various processes and product lines. These broad-based goals are being pursued in four major areas, namely iron making, steel making, product development, and automation.

In developing new products, one of the vital inputs is to know in clear terms the behavior of the alloy during microstructure evolution for a given thermo-mechanical treatment. In spite of better control systems available today with our experimental rolling mill, the steel processing industry has remained largely unchanged. Moreover, the degree of freedom in varying a number of processing parameters simultaneously in a most precise manner was also constrained due to the inherent limitations of material handling at the time of rolling.



The installation of the Gleeble 3500C system at RDCIS in March 2001 has opened up a new opportunity in the simulation of thermo-mechanical experiments in a most scientific and accurate manner. This facility has been acquired with the generous grant sanctioned by the Ministry of Steel, Govt. of India, under the Steel Development Fund, for pursuing the project, “Simulation on Thermomechanical Processing and Hot Workability Studies of High Strength Steels.” In this exercise, our aim was development of cost-effective alloy design, optimized processing, and mathematical modeling of high-strength steels, namely hot rolled microalloyed steel and quenched and tempered variety HSLA-100 steel. In view of this, the approach was to evolve leaner chemistry steels for these two selected categories of high-strength steels through comparative evaluation of properties of a series of alloys prepared and processed in the laboratory in a controlled manner. Finally, a comprehensive understanding of sequential evolution of microstructure under varied conditions of simulated hot deformation and linking them with the final microstructure and properties was established. The latter activity formed an integral part of mathematical modeling of microstructure and properties of microalloyed hot rolled steel.

During the course of these studies, the Gleeble 3500C system was extensively utilized in determining two critical temperatures, namely phase transformation temperatures (Ar3 and Ar1) under different cooling rates through measurements of dilations of specimens and recrystallization stop temperature (Tnr) for a number of prepared alloys. This led to clear understanding of the implication of cooling rates and microalloy content and the degree of undercooling. Determination of Tnr was particularly relevant in assessing the influence of % reduction given below Tnr on the efficiency of ferrite grain refinement. Such experiments also provided a comprehensive understanding on the sequential evolution of ferrite grains with the progressive increase in strain. Kinetics of recrystallisation (both static and dynamic) were thoroughly examined for the first time by conducting a series of hot deformation simulation tests at different temperature, strain, and strain rate. The computation of activation energies for different alloys showed their significant influence on the extent of microalloy additions. It has been observed that refinement of ferrite grains through repetitive reductions during high temperature deformation was more amenable for both static and dynamic recrystallisation to take place particularly for lower content of microalloy elements.

RDCIS is now flowing with many innovative ideas in utilizing this high tech facility for development of new products as well as improvement in the quality of existing grades of steel. These objectives will be pursued following two broad approaches (i) optimization of processes like continuous casting, hot rolling, annealing and welding, and (ii) modification of existing product chemistry in terms of leaner alloy design.

We consider the Gleeble 3500C as an essential tool in our quest to produce world-class products at a competitive price.

ASM Materials Solutions Show Conference and Exposition— Greater Columbus Convention Center, Columbus, OH, October 8–9, 2002

Where engineers will find answers on metals and materials, new processes and applications, testing and characterization, failure analysis, and more.

Be sure to stop by Booth 400 to speak with DSI applications engineers.

For additional information about the conference, contact:

ASM International
9639 Kinsman Road
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Fax: 440-338-4634
Web: www.asminternational.org

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Poestenkill, NY 12140 USA

Maximize Uptime through DSI's Extended Maintenance and Service Programs

To make sure you get maximum uptime and productivity from your Gleeble system, DSI offers four different maintenance and service programs.

Type I
Factory Maintenance—
for All Gleebles

Provides repair or replacement components. There is no on-site service included in the Type I program. Any on-site service must be purchased separately at regular service rates. Should on-site service be purchased, the cost of any covered parts used during on-site service are included under the Type I factory maintenance program.

Type II
On-Site Service and Maintenance—
for All Gleebles

Provides for repair or replacement of parts, as provided with Type I Programs, plus on-site service. One on-site service call per year for repair and calibration will be provided at no charge. Service will be scheduled at your request. You may elect to use an on-site service visit for applications seminars and training of customer staff. The total number of days is limited to 2 days per visit. Additional days are available at regular service rates. Unlimited telephone, fax and email hot line support for applications and operation assistance is provided at no charge with this program.

Type III
Software Maintenance—
for Gleebles with Series 3
Digital Control Systems

Ensures your Series 3 Digital Control system is kept up to date with the most recent version of software for your machine/hardware configuration. Without this plan, software updates must be purchased separately. Type III Software Maintenance Programs are only available for Series 3 Digital Control systems.

Software support for MS-DOS based programs has been discontinued. Hardware updates must be purchased separately as needed. Prior to accepting a contract, DSI will inspect the machine and advise if hardware updates are necessary.

Type IV
Premium Coverage Maintenance—
for Gleebles with Series 3
Digital Control Systems

Provides for on-site service and parts repaired or replaced. This program is available for Gleebles with Series 3 Digital Control Systems. Two on-site service calls per year for repair and calibration will be provided at no charge. Service will be scheduled at your request. All software upgrades to maintain the latest versions of software are included. Computer hardware upgrades to the desktop and embedded control computer to provide hardware to operate the latest version of software are included.

Type I, II and IV Programs cover all parts, components and sub-assemblies of the Gleeble Systems, including all options purchased from DSI. This article provides only the highlights of each program. For complete details, including any conditions and exclusions, contact us at DSI.

Did you write a Gleeble-related paper? We want to hear from you!

The Gleeble Newsletter tries to keep its readers around the world informed about all the latest developments regarding physical simulation and materials studies conducted on Gleeble systems.

As a result, if you or one of your colleagues has published a technical paper that discusses research or testing conducted using a Gleeble, we would like to know about it. Please send a copy of the paper to David Ferguson at our address, or email to: dave@gleeble.com.