Dynamic Systems Inc.
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The Gleeble® NEWSLETTER

Fall 1995

Gleeble Application Profiles:

The Gleeble 1500 at Tata Iron & Steel, India

TATA STEEL, a pioneer in quality steel manufacturing in India, has had a very long and distinguished career. The first ingot was rolled in the plant in 1912; thereafter the plant has gone from strength to strength, and today the saleable steel figures stand at 2.3 Mtpa. The plant boasts of a modern bar and rod mill of 0.3 Mtpa and a 1 Mtpa state-of-the-art hot strip mill, along with billet and slab casters. Several high-value steels have been included in the product-mix of the plant. Both the bar and rod mill and the hot strip mill have very sophisticated thermomechanical processing facilities. The products from these mills have to be produced with international quality and in a cost-effective manner.

The R&D Division has been active in looking into all aspects of continuous casting of billets and slabs, flats products from the hot strip mill, long products from the bar and rod mill, as well as some high-quality products from the bar forging and rolling mill. It is towards this end it was felt that the use of a simulator was needed, and a Gleeble 1500 machine from DSI was installed in November, 1992. The machine, the first of its kind operating in India, has the capability to simulate continuous casting, hot deformation behavior, as well as welding of metallic materials.

The main objectives of the work using the simulator at Tata Steel's R&D have been:

- To provide a preview of the structure and property development in the products of the mills mentioned above, under simulated conditions that would eliminate expensive plant trials.
- To provide first-level validation of the predictions made through mathematical modelling before attempting any validation in the actual plant.

In the area of continuous casting, some comprehensive studies have been undertaken to look into crack-sensitivity of billets and slabs under various plant conditions. In order to develop such a model, a number of inputs with regard to material property of steels at different temperatures and strain rates must be made, and the Gleeble 1500 has been very useful in these cases. These data have now been incorporated in the model, and the predictions from the mathematical modelling are being validated once again in the Gleeble 1500, using a melting-resolidification schedule. The plant data collected have also shown excellent matching.

In the area of flat and long products, the Gleeble 1500 has been used exten-

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DSI on the World Wide Web

DSI can be found on the Internet at:

http://www.gleeble.com/gleeble

Information related to DSI products and applications are available at this web site. In addition we are posting ISPS conference information and have provisions for electronic submission of ISPS abstracts via Internet. We are continuously updating and adding information to this web site. Next time you are "surfing the net" stop for a visit at the DSI home page.

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Recent Gleeble Papers

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The Influence of Welding on the Creep Rupture Strength of 9%-Chrom Steel P91

by W. Bendick, K. Niederhoff, G. Wellnitz, M. Zschau, and H. Cerjak

This paper deals with the influence of welding on the behavior of P91 steel in respect to creep behavior, toughness and SRC susceptibility based on microstructural investigations. HAZ-simulation technique were applied to study the microstructural development in various regions of the HAZ. Hardness tests and constant strain rate tensile test of HAZ simulated specimens indicated the position of the lowest creep resistance with a weldment. Long term creep tests applied on actual weldments were performed. The results showed that a local softened zone, located in the intercritical zone of the HAZ governs, the long term creep behavior. Steels containing 9–12% Chromium have been developed for more than 30 years now, and these developments are still ongoing mainly with the objective of extending the operating temperature up to 600°C and higher. Owing to their favorable physical properties such as higher thermal conductivity and low coefficient of thermal expansion, coupled with higher resistance to thermal shock, these steels offer advantages over austenitic stainless steels offer advantages in several applications, e.g., as material for modern high efficiency fossil fired conventional power plants. In Europe, particularly in Germany, the gap between the application range of the ferritic steel P22 German designation (10CrMo910) and austenitic stainless steels were successfully bridged in the past by using the 12% chromium steel X20CrMoV121. Since 1975 a new modified 9% Chromium steel was developed in the U.S. under the leadership of ORNL and standardized as P91/T91 in ASME, German designation X9CrMoVNb91, in the early 1980s. Although the steel was originally developed for fast breeder reactor components operating at about 600°C, it was considered later as a prospective candidate material for pipes in fossil fired power plants operating above 540°C. As a part of an extensive program carried out by Mannesmann in cooperation with TU-Graz on this steel, special attention was drawn on the weldability and the behaviour of welded components made out of this type of steel. In this report, results of the investigations related to the weldability of P91, mainly the behavior of the HAZ, will be given and discussed. The results concerning the behavior of the base material, their fabricability and their service behavior was reported elsewhere.

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Effects on Hot Ductility and Sensitivity to Cracking in a Carbon Steel

by Dang Zijiou, Wu Na, Zhang Yan, Cai Kaike, and Wang Xuejie

The hot-ductility test method was employed to simulate the continuous casting at the temperature range from 600°C to the melting point of 1045 steel. Factors including thermal history, strain rate and cooling rate affecting to the embrittlement and sensitivity to cracking at the elevated temperatures, and mechanism of cracking were investigated.

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Yield Properties of Tungsten and Tungsten Heavy Alloys

by Kenneth F. Ryan and Robert J. Dowding

This report describes the progress made in dynamic thermomechanical investigations, using the Gleeble 1500 of the yield properties of tungsten heavy alloys. This study describes properties of tungsten heavy alloy at elevated temperatures and strain rates, that can be useful in the modeling of long rod kinetic energy penetrator behavior.

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Study of the Martensite Structure at the Weld Interface and the Fracture Toughness of Dissimilar Metal Joints

by Zhihui Wang, Biyu Xu, and Ciqi Ye

Deterioration of toughness in the HAZ is more a result of coarse-grained bainite than of martensite. In austenitic-ferritic dissimilar metal welded joints, the content of alloying elements in the transition zone varies continuously from the heat-affected zone (HAZ) to the weld metal. Due to the low level of Ni content, a martensite layer is formed in this zone during the welding process. The Charpy impact test performed previously by other researchers indicated that the martensite layer was the weakest zone in toughness in the joints. In this study, color metallography and transmission electron microscope (TEM) analysis were used to show the martensite structures at the weld interface. The results show that the structures of the martensite layer at the weld interface are lath martensite. The martensite starting points vary with the distance from the fusion line and are controlled by composition gradient. The boundary of the transition zone could be divided in two types: the “blurred” type and the “sharp” type, which are controlled by diffusion of elements. A simulation test, in which specimens were prepared by casting steels in accordance with the compositions of the martensite layer, was conducted to evaluate the fracture toughness of the martensite layer. The experiments were also made to investigate the distribution of toughness in the different regions of the joints. The results show that the weakest region in toughness is the dissimilar metal joints is not the martensite layer but the overheated zone in HAZ. The fracture in the overheated zone is caused by the coarse-grained bainite, and it appears as a quasicleavage fracture; however, in the martensite layer, it appears as a tear fracture.

The Gleeble at Tata Iron & Steel

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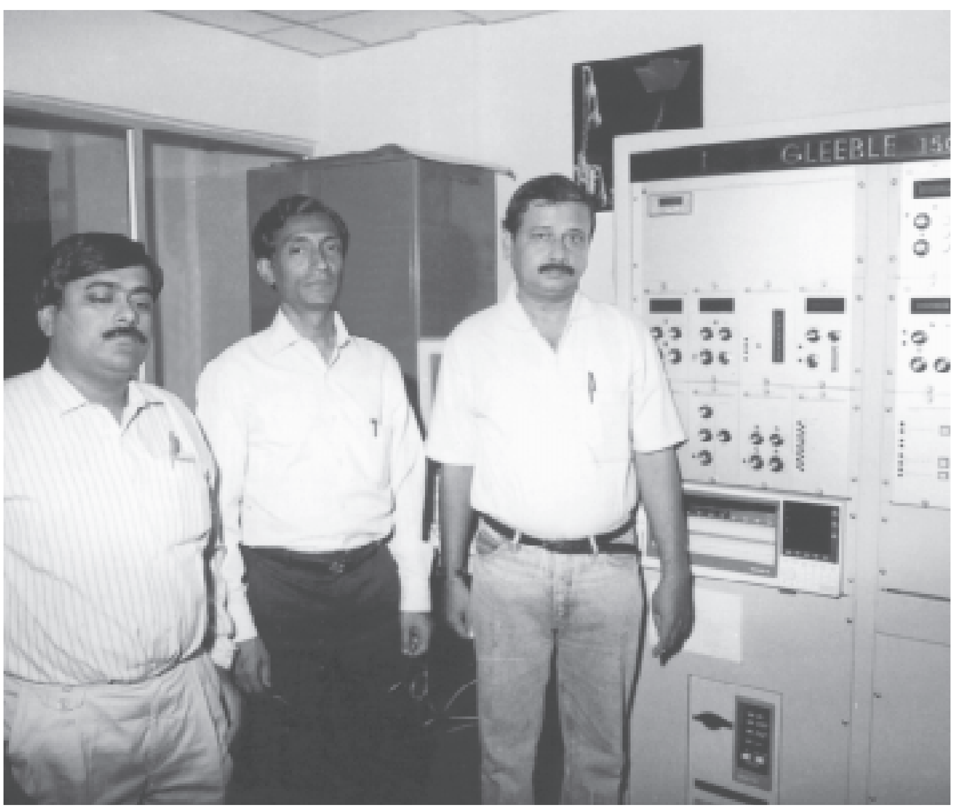
sively. To begin with, for the hot strip mill, determination of high-temperature properties and continuous cooling behavior of various grades of steels has been done. Further, the five-stage finished rolling simulation has been carried out and optimization of cooling strategies on the run-out-table (ROT) has been accomplished, using the simulator. The steels studied so far include LPG cylinder grades, deep drawing and low carbon grades, where the product properties from the hot strip mill have been generally within the predictions made. Similarly, in the bar and rod mill, which incorporates a STELMOR-line (for achieving controlled cooling), the optimization of process parameters has benefitted immensely from using the data generated by the Gleeble 1500. Here, the contributions have specifically been towards prediction of the microstructure at different cooling rates and hence mechanical properties.

Rolling load calculations, particularly for the hot strip mill, have been a major area of concern. Here, high temperature flow stresses have been determined for several grades in the Gleeble 1500, and using internationally accepted relationships, rolling loads have been pre-estimated. In all cases, the predicted loads have correlated very well with the estimation made on the Gleeble 1500.

As Dr. Ing. O.N. Mohanty, Director of the R&D, says: "We cannot play around with the multimillion-dollar facilities in the plant for optimizing processing parameters, hence the Gleeble 1500 is invaluable in generating relevant information. Our experience so far with the Gleeble 1500 surely places a great deal of credence and credibility on its data and the machine is busy every day, providing valuable information. In the future, the Gleeble 1500 will help us design our processing schedules, so as to produce a range of properties without having to take recourse to a varied chemistry of steels—a dream that should turn to reality soon."

— *Dr. Ing. O.N. Mohanty*
Director, Research and Development
The Tata Iron & Steel Co., Ltd.



Mr. A. Halder, Assistant Manager, R&D, Dr. Ing. O.N. Mohanty, Director, R&D, and Mr. R.N. Chattopadhyay, Manager, R&D, pose with the Gleeble 1500 at The Tata Iron & Steel Company in Jamshedpur, India.

ISPS Call for Papers

The 6th International Symposium on Physical Simulation will focus on the following areas of research:

- Physical simulation of welding processes for low and high strength steels, aluminum alloys, stainless steels, titanium alloys, and other advanced materials.
- Physical simulation of hot deformation processes, including hot rolling and forging.
- Physical simulation of heat treatment processes.
- Physical simulation of casting, melting, and solidification processes.
- Thermal and/or mechanical fatigue and other thermal/mechanical process simulations.
- Physical simulation of semi-solid processing of materials.

Investigators who are researching these areas of physical simulation are invited to submit abstracts to:

ISPS Technical Director
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Paper Submission Schedule

- Abstracts due — January 1, 1996
- Presentation requirements mailed to authors — January 1996
- Papers due at conference — June 3, 1996
- Proceedings printed and mailed — Fall 1996

Conference proceedings will be published by DSI.

Come See Us at Materials Week '95!

You can see us at the ASM/TMS Materials Week, booth 501, October 29 through November 2, 1995, to be held at the Cleveland Convention Center, Cleveland, Ohio.

For information about this show, contact ASM International, Materials Park, Ohio 44073-0002, telephone (216) 338-5151, or fax (216) 338-4634.

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., or faxed to us at 518-283-3160.

Dynamic Systems Inc.

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Upcoming Conference Presentations by DSI Personnel

37th Mechanical Working and Steel Processing Conference

Dates:	October 22–25, 1995
Location:	Hamilton, Ontario, Canada
Additional Info:	Iron and Steel Society, Inc. 410 Commonwealth Drive Warrendale, PA 15086-7512 Tel: 412-776-1535 Fax: 412-776-0430
Presentation 1:	"The Effect of Hot Working Conditions on the Austenite Decomposition in SAE 4120 Steel," by E.B. Damm, Dynamic Systems Inc., C.J. Van Tyne, D.K. Matlock, and S.W. Thompson, Colorado School of Mines.
Session Info:	Product Physical Metallurgy III: Recovery and Recrystallization in Steel III: Hot-Rolled Steel. Tuesday, October 24, morning.
Presentation 2:	"Physical Simulation of Metal Working Processes: An Overview of Techniques and Benefits," by E.B. Damm, Dynamic Systems Inc., and C.J. Van Tyne, Colorado School of Mines.
Session Info:	Bar Products and Forgings I: Monday, October 23, morning.

TMS Fall Meeting, ASM Materials Expo

Dates:	October 29–November 2, 1995
Location:	Cleveland, Ohio USA
Additional Info:	ASM International Materials Park, OH 44073-0002 Tel: 216-338-5151 Fax: 216-338-4634
Presentation:	"The Effect of Hot Working Conditions on the Austenite Decomposition in SAE 4120 Steel," by E.B. Damm, Dynamic Systems Inc., C.J. Van Tyne, D.K. Matlock, and S.W. Thompson, Colorado School of Mines.
Session Info:	Deformation and Fracture: Ferrous Materials — TMS general abstracts. Tuesday, October 31, 10:10 am.