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The Gleeble® NEWSLETTER
Spring 2002

Gleeble Application Profile

The Gleeble at the Illinois Institute of Technology

The Illinois Institute of Technology's Thermal Processing Technology Center (TPTC) is aimed at enhancing collaborative multi-disciplinary research between industry and the university. Center participants include faculty, post-doctoral research associates, graduate and undergraduate students from the university, representatives from member industrial companies and researchers from federally funded laboratories and other universities.

The missions of the center are to:

- perform high quality basic research of interest to industry in a cost-effective manner
- provide a mechanism whereby technology can be transferred to industry
- enhance the human resources available to the industry.

Funding for the Center comes primarily from industry membership fees, state funds and other external research grants, as well as NSF funds, and University contributions in the form of tuition scholarships and reduced overhead.

According to Dr. Philip Nash, Professor of Metallurgical Materials Engineering and Director of TPTC, the Gleeble 3500 physical simulation system installed in 2001 is central to achieving the goals of the Center.

"The Center is driven by our industrial members," Dr. Nash says. "They make suggestions for projects, and we carry them out with the help of graduate students, post-doctoral students, and supervising faculty members."

At present there are four projects at TPTC that make heavy use of the Center's Gleeble. The first, undertaken for Union Tank Car, is aimed at examining the influence of niobium content of steel on the mechanical properties of weld heat affected zones. Union Tank makes railway tank cars that are frequently used to transport materials under pressure, and the company would like to build in a high degree of impact resistance, particularly at lower temperatures.

Students Gang Shi (left) and Chirag Sha perform Gleeble tests on 1080 steel, standard specimen type N, at IIT's Thermal Processing Technology Center.

The Gleeble is being used to simulate different regions of the HAZ by controlling the thermal profile. "These are impact samples," Dr. Nash says. "We simulate the HAZ and then subject it to charpy impact at different temperatures. A graduate student is conducting the project under the supervision of faculty member Dr. Bob Foley. Bethlehem Steel is supplying steels of different compositions for the project.

A second project is investigating the influence of alloy content on the ductility of 410 stainless steel. Dr. Nash says, "We know that there are variations in the

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DSI Co-Sponsors THERMEC 2003

International Conference on Processing & Manufacturing of Advanced Materials

DSI is a proud co-sponsor of THERMEC 2003, planned for July 7–11, 2003 in Leganés, Madrid, Spain. THERMEC 2003 will focus on recent advances in the overall field of science and technology of fabrication and manufacturing, structure and properties, and applications of both ferrous and non-ferrous materials.

Technical presentations will consist of invited papers by international experts from various countries, with papers by others working in relevant fields.

Topics will include Al and Al alloys, Mg Alloys, Ti Alloys, HSLA/IF and Stainless Steels, High Nitrogen Steels, Composites, Intermetallics (Structural and Functional), Amorphous Metallic Materials, Superalloys, Nanocrysalline Materials, Severe Plastic Deformation, Biomaterials, Textures, Ecomaterials, Thin Films, Friction Stir Welding/Processing, Functional Materials Processing, Powder Metallurgy, Welding and Joining, Residual Stresses, Modelling, and Surface Engineering/Coatings.

All accepted papers (oral/poster) presented at THERMEC 2003 will be included in the Proceedings to be published in book form.

Important Dates

October 25, 2002: Abstracts due

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Recent Gleeble Papers

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Physical Simulation of Continuous Casting and Direct Hot Rolling in Steels

by Hirowo G. Suzuki

The continuous casting (CC) and direct hot rolling (CC-DR) just after CC, are one of the most important processes to produce homogeneous high quality steels with an excellent productivity as well as low cost in steel industry. This outstanding technique is succeeded only on the condition that CC slabs are free from surface/ internal defects and no cracking occurs during CC-DR process. The spectrum of ductility and strength for a wide range of temperatures is shown in Figure 1. Brittle fracture occurs due to the difficulty of slip deformation at sub-zero temperature, hydrogen embrittlement due to the low solubility of H_2, 500°F embrittlement due to the interaction between carbon or –nitrogen atoms and dislocations, temper embrittlement due to the segregation of impurity elements such as *P*, *Sn*, *Sb* to the grain boundary. The hot stage is above *Tm*/2 (in Kelvin unit). This stage is classified into three regions I, II, III according to the characteristics of the embrittlement, which is shown in Table 1. In this paper, systematic results of the embrittlement due to (oxy-)sulfide precipitation, phosphorus and AIN precipitation on the grain boundary are emphasized in the II and III regions.

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Effect of Thermomechanical Circulation on Cobalt Binder Phase Structures of WC-20wt%Co Alloys

by Wu Liu, Manshan Lu, Shoji Goto, and Setsuo Aso

The effect of thermal or mechanical and thermomechanical circulation on cobalt phase structure of WC-20wt%Co cemented carbides have been investigated in this paper. These circulations have been carried out through Gleeble 1500 simulator. Cobalt phase's crystal structures and the alloy's microstructure have been analyzed and observed respectively by Siemens D-500 XRD, Hitachi X-650 SEM and H-800 TEM. The results show that the relative volume percentage of b – Co (fcc) in alloys all decreases after variety of circulation, and e – Co (hcp) increases. Under the same condition of thermomechanical circulation, of b – Co in as heat-treated specimens is much more than that in as-sintered. After 500°C ~ 600°C/100 ~ 427 MPa (axial pressure stress) and 104 times circulation to WC-20%Co alloy, b – Co of the quenched state and tempered state after quenched are respectively 5.4 and 7.2 times that of as-sintered state. An amount of b – Co through thermomechanical circulation is 71.3% and 66.5% respectively less than that through thermal and mechanical circulation alone, under the same condition of sintering and circulating. There are many voids and microcracks to have been nucleated interface between WC and Co in the region rich in fine carbide particle through the thermomechanical circulation at 500 ~ 600°C/100 ~ 427 MPa (pressure stress) and 104 times circulation. By means of vacuum tempering at 600°C / 5 hrs after oil quenching at 1300°C, service life of the alloy's punch die has been increased by 2.2 times compared with that of conventional as-sintered. Because the condition of thermomechanical circulation has analogy to that of punch die working, the service life prolongation of as heat-treated alloy very possibly relates to dynamic decreasing amount and extent of b – Co (fcc) during their practical use.

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Study of Austenite Decomposition During Continuous Cooling Using Gleeble 1500 Thermo-Mechanical Simulator

by Firdosh Kavarana and Shiv Brat Singh

Under this investigation, efforts were made to construct continuous cooling transformation diagrams from "dilatation" curves obtained with the help of a Gleeble 1500 Thermo-mechanical Simulator along with the characterization of various microconstituents present in the microstructure for two grades of steel processed through the Hot Strip Mill (HSM) at the Tata Iron and Steel Company, India. A new technique has been developed to find out the kinetics of transformation at temperatures intermediate between the start and finish transformation temperatures using the "dilatation" curve. The transformation curves (S-curves) obtained by this method and by the conventional quenching method are compared and they have been found to be in good agreement.

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High Temperature Ductility Loss of 16MnCr5 Pinion Steels

by Haiwen Luo, Pei Zhao, and Zijiu Dang

A wide ductility trough covering from 700 to 1100ºC is observed in the curve of Reduction of Area (RA) vs. temperature for 16MnCr5 pinion steel. At 750ºC, corresponding to the minimum of RA, it is grain boundary sliding that controls its hot ductility rather than usual Deforming Induced Ferrite (DIF), which can only appear just below 750ºC and slightly improve hot ductility. The volume fraction of ferrite is dependent on the strain and strain rate. Firstly a critical strain must be necessary for formation of DIF, then with strain rate increasing, the volume fraction of DIF decreases but RA is elevated. In the γ phase region hot ductility is seriously deteriorated because of grain boundary sliding promoted by oxides and sulfides at the grain boundary and recovered because of dynamic recrystallization at higher temperature; while strain rate increases, ductility is improved as there is insufficient time for cracks to propagate along the γ grain boundary, as well as dynamically precipitating, and ductility trough becomes narrower because the temperature for onset of dynamic recrystallization decreases. In addition, $\gamma \rightarrow \alpha$ phase transformation introduced by temperature drop before the tensile test encourages precipitation of AIN and impairs ductility.

The Gleeble at IIT

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chemistry of 410 stainless that are within the specification for that steel. The question is: how much does in-spec variation in the chemistry affect the physical properties? Our preliminary results are showing that there are some large variations."

This project is being conducted for Scot Forge, a company that regularly forges using 410 stainless and which is very concerned about the ductility for forging. Using the Gleeble for some fairly simple hot tension tests, a graduate student, working under Dr. Bob Foley, has discovered that if the sulfur content is on the high side of the specification, there can be difficulties in forging.

Another research effort, being undertaken for the potential benefit of all TPTC members, is looking at the stress accelerated tempering of steel. "Making hot working dies from tool steels, such as H13, that are used, for example, as extrusion dies is extremely costly, and the manufacturers that use the dies would naturally like to be able to extend the lifetime, and the return on investment, of these dies as much as possible," Dr. Nash says.

He adds, "To prepare H13 for its function, you give it a hardening heat treatment and a number of tempering heat treatments. After the hardening treatment, the steel is brittle, but the tempering restores some of its toughness but takes away some of the hardness. Unfortunately, when the hot working die is in use, a kind of continuous tempering process can take place, and eventually the hardness drops so low that the die becomes useless."

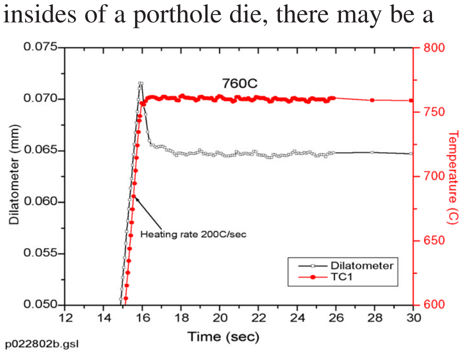
"Normally," he says, "the use temperature is below the tempering temperature. But when stress is applied, such as on the insides of a porthole die, there may be a synergistic effect that contributes to tempering and loss of hardness. We're using the Gleeble to impose a stress at typical tempering temperatures to see if hardness is a function of the applied stress. We're taking advantage of the fact that there is a thermal gradient in a Gleeble specimen, and we're using multiple thermocouples to determine the exact temperatures along the sample."

The H13 steel project is being conducted by a graduate student supervised by Dr. Nash and Dr. Joe Benedyk.

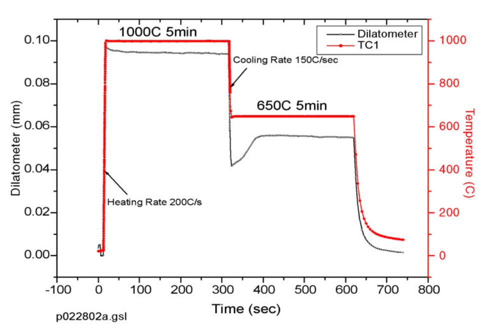
The fourth Gleeble-related project at TPTC involves a Ph.D. student Gang Shi working under Professor Calvin Tszeng. They are conducting a series of investigations to determine CCT curves on the steels and to model phase transformation kinetics. They are taking advantage of the Gleeble's capability to heat and cool samples very rapidly and using a dilatometer to measure diametral strain.

Dr. Nash says, "Instead of simply having a recipe for heat treatment that is general, we will be able to specify more accurately what the correct heat treatment should be to achieve certain characteristics. We also want to extend this to the effects of stress. There are many situations in which stress may be imposed during a phase transformation, yet very little work has been done on the effects of stress on CCT curves."

He adds, "It's only with a Gleeble that you can do this kind of work. Ultimately, all this data will be used in modeling the thermal processing of materials. The Gleeble is invaluable at both ends of the process: to establish the data that is used to feed the computer model and to conduct experiments that are essential to validate the model."



The pearlite-to-austenite, iso-thermal phase transformation occurs at a rate of the same order as the heating rate of 200°C/sec.



The initial pearlite is obtained by thermal process shown here. Material is 1080 steel, standard specimen type N.

THERMEC 2003

Continued from Page 1

November 25, 2002: Notification to authors of abstract acceptance

February 25, 2003: Manuscripts due, advanced registration for speakers/authors

May 25, 2003: Final program on website

July 7–11, 2003: THERMEC 2003 Meeting

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4th International Conference of Physical and Numerical Simulation of Materials Processing

First Announcement and Call for Papers

The 4th International Conference of Physical and Numerical Simulation of Materials Processing will be held at Novotel Shanghai Yuan Lin Hotel from May 26–29, 2003. The Novotel Hotel is located at the center of Shanghai, the biggest city in China and the place where the APEC 2001 Conference was held.

The conference will provide a forum for the exchanges of ideas and information, and presentation of papers dealing with physical and numerical simulation as well as their application thermomechanical processing of materials.

Call for Papers

Conference organizers are calling for papers on the following topics:

- Physical simulation and numerical modeling of materials and thermomechanical processing.
- Materials, including HSLA steels, TMCP steels, stainless steels, aluminum alloys, titanium alloys, composites, intermetallics, and other advanced materials, such as ultrafine grain materials and nanometer materials.
- Industrial processes, including welding, heat treatment, stamping, rolling, casting/continuous-casting, forging, extrusion, and other advanced technologies.
- Primary theories of physical simulation and numerical modeling.
- Development and application of numerical simulation software.
- Prospects of physical simulation and numerical modeling on materials, and thermomechanical processing in the 21st century.

All abstracts of papers less than 300 words, manuscripts, and the presentations are requested in English and should be sent to the organization committee of the conference. All full papers in English will be published in the Journal of Materials Science and Technology in 2003.

After the conference, the organization committee will arrange a tour program for participants and companions to visit Shanghai City, Baoshan Iron & Steel Group, Shanghai Jiaotong University, and Zhouzhuang, the oldest town south of the Yantze River.

For more information, please contact:
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Important Dates

Abstract deadline: July 10, 2002
Notification acceptance of the abstract: July 30, 2002
Manuscript deadline: December 25, 2002

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