Dynamic Systems Inc.
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The Gleeble® NEWSLETTER

Spring 1995

Customer Service and Technical Support

DSI takes great pride in its ability to provide prompt, accurate service and technical support to you. Very often DSI can help you via phone or fax support, which offers great savings over on-site visits. However, sometimes our responsiveness to your problems is delayed because we don't get all the information we need when a problem is initially reported.

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ISPS Symposium Set for USA

The 6th International Symposium on Physical Simulation, sponsored by Dynamic Systems Inc., Edison Welding Institute, ASM International and FIERF (Forging, Industry, Education and Research Foundation), will be held June 3–5, 1996 in Columbus, Ohio, U.S.A.

This international symposium will provide a forum for exchange of information, presentation of papers dealing with physical simulation of metallurgical processes, workshops on physical simulation techniques, and a tour of the Edison Welding Institute facilities. The official language of this meeting will be English.

The symposium will deal with physical simulation of:

- Welding processes for low and high strength steels, aluminum alloys, stainless steels (particularly duplex stainless steels), titanium alloys, and other advanced materials.
- Hot deformation processes, including hot rolling and forging.
- Heat treatment processes.

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Gleeble Application Profiles:

The Gleeble at Dofasco

Dofasco Inc., an integrated steel maker headquartered in Hamilton, Ontario, Canada, produces flat-rolled steel mainly for the automotive industry. John Worobec, Senior Research Engineer—Thermal/Mechanical Simulation, works in the research and development department and focuses on solving production problems.

In 1983, Dofasco brought a new hot rolling mill on line to roll HSLA steel. "If it isn't done right, HSLA can produce a lot of weird microstructures," Worobec says. "One of the reasons we bought a Gleeble 1500 was to determine the hot rolling characteristics of our steels. The essential question was: how do our bread and butter products transform during the hot rolling process?"

"Most of our initial work with the Gleeble was to develop CCT (continuous cooling transformation) diagrams for 11 typical grades of steel. We were able to tell the hot rolling people where their finishing and coiling temperatures should be in order to produce uniform mechanical properties, particularly for automotive applications. We were also able to tell them they need very low cooling rates to avoid intermediate structures," Worobec says, adding: "We still produce CCTs for any new material we make."

He reports, "Unfortunately, we also had to tell them 'You're never going to make your critical cooling rate with the rolling mill in its initial configuration.' They had to extend the hot rolling table at a cost of $50 million. Now Dofasco has

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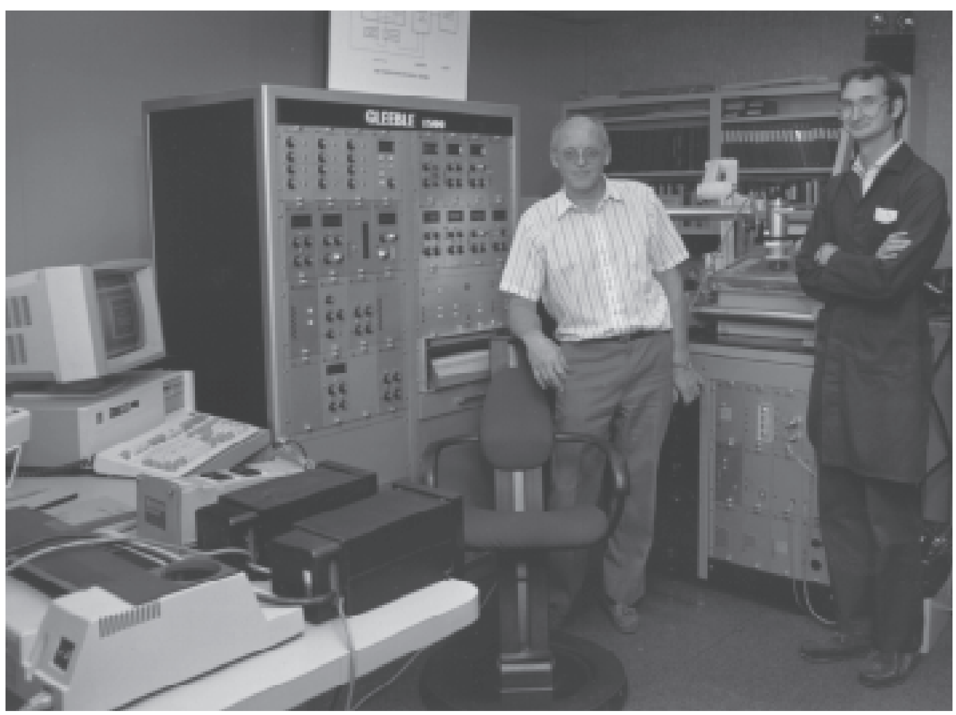

John Worobec (left) and David Hall, a research engineer in charge of the torsion test machine, help Dofasco to characterize materials and optimize processing.

Recent Gleeble Papers

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HAZ Tempering Phenomena of Multipass Welds in Baintic HP Rotor Steels

by D.A. Wojnowski and J.E. Indacochea

Studies have been conducted on the weldability of an ASTM A 470-Class 8 high pressure (HP) steam turbine rotor steel. The primary concern of welding in the higher temperature sections of the rotor is the occurrence of reheat cracking resulting from post-weld heat treatment or during service at high operating temperatures. Results from our earlier investigation demonstrated that reheat cracking did not occur because of the grain refinement of the coarse grain heat-affect zone (CGHAZ) due to the multi-pass weld procedure. However, stress rupture testing revealed that the weldment strength was limited to the material properties of the temper zone of the HAZ which existed adjacent to the unaffected base metal. Microhardness values showed a significant decrease in the hardness of this area. Optical microscopy could not differentiate the microstructural characteristics between the temper and grain refined heat-affect zone (GRHAZ). Electron microscopy and energy dispersive analytical x-ray elemental mapping revealed an increase and coarsening in molybdenum carbides in the temper area when compared to an area in the base metal. Transmission electron microscopy work on thin foils from the base metal and temper zones was conducted to determine the carbide morphology of the respective zones. The analysis determined not only an increase in carbides, but a coarsening of existing carbides occurred. Gleeble simulation work is being conducted to understand the required temperature profile needed to produce the temper zone. Recent trends in the power industry have included the repair welding of high pressure high temperature steam turbine rotors. The primary concern of welding in the higher temperature sections of the rotor is the occurrence of reheat cracking resulting from post-weld heat treatment or during service at high operating temperature. Results from the G.S. Kim investigation demonstrated that reheat cracking did not occur because of the grain refinement of the CGHAZ due to the multi-pass weld procedure. The research also showed that the strength of the weldment was limited by the inferior stress rupture properties of the weld metal. A subsequent investigation on filler metal selection found the optimum welding wire. However, elevated temperature tensile and stress rupture testing revealed that the weldment strength was limited to the material properties of a temper zone of the HAZ which existed adjacent to the unaffected base metal. Previous studies pertaining to the weldability of 1Cr-1Mo-1/4V rotor steels have revealed that an extensive tempering has occurred during the SAW process and to a lesser extent during the TIG welding process. Hippsley and Yamaura et al., reported on the tempering in 2-1/4Cr-1Mo steel, and Panton-Kent on the tempering of weldments in 1Cr-1Mo steel. This temper zone, which is adjacent to the base metal in the GRHAZ, occurs without an apparent change in microstructure when viewed using standard optical microscopy. The purpose of this study is to determine the factors that affect the development of the temper zone and to characterize the tempering phenomenon with respect to microstructural and submicrostructural changes. The study includes the use of optical, scanning and transmission electron microscopy, and stress rupture testing at elevated temperatures. Gleeble simulation was conducted to further understand the welding temperature profile effects on the development of the temper zone.

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Basic Aspects of Weldability of HSLA Steel, Type X80

by H. Cerjak and H. Kammerstetter

The toughness behaviour of simulated heat affected zone (HAZ) microstructures from thermomechanically controlled processed (TMCP) steels of type X70 and X80, containing small amounts of V, Nb and Ti has been investigated as a function of welding parameters. The effect of post weld heat treatment (PWHT) (580°C/2h) on toughness behaviour has been studied. In the “as welded” condition the simulated microstructures show good toughness behaviour. Especially at low heat inputs, PWHT leads to a loss of toughness in “coarse grained” microstructures. This effect is related to the chemical composition of the materials tested. The impact toughness is influenced by the weld-thermal-cycle and PWHT conditions, which determine the transformation behaviour and the dissolution of (Ti,Nb)(N,C) precipitates, as well as the content of nitrogen in solution. PWHT embrittlement has been described by a mathematical model for precipitation dissolution using thermodynamic and kinetic approaches. TMCP steels are the product of extensive optimization of strengthening mechanisms and toughness properties in steels. The development of TMCP steels has been guided by economic considerations in steel production as well as in manufacturing processes such as machining, cutting and welding. The TMCP process leads to ultra fine grained microstructures with high strength and impact toughness properties mainly with additions of microalloying elements. TMCP steels have usually low carbon equivalents, therefore they can be welded with high speed and without preheating. Due to their well-balanced alloying concept, TMCP steels can show significant changes of their mechanical properties, when they are exposed to thermal treatments. The present paper is an excerpt of a research program which was initiated to quantify the properties of the HAZ microstructures of TMCP steels. Experimental and numerical results are shown for two steel types, i.e., type X70 (in this paper called “material 20”) and type X80 (in this paper called “material 21”) with different amounts of V, Nb, Ti and N.

The Gleeble at Dofasco

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two run out tables—one short, one long. We are concentrating on making high-end products—HSLA stuff. It's very difficult to make, but that's where the big money is."

Prudently, anytime Dofasco is getting ready to make a new steel, small quantities are produced in a pilot vacuum induction furnace. Worobec and his colleagues take samples of the new steel and use the Gleeble to determine what the hot rolling characteristics need to be.

Worobec also measures the flow stress characteristics of various steels. "We start with a slug-type sample and compress it. We use tantalum foil to reduce friction when the sample spreads under compression. As a check, we also have taken some of the sample materials and done the same work on a torsion tester. The results produced by the two different machines are very close. The Gleeble, which is equipped with a data acquisition system, produces good true stress/true strain curves for us," Worobec says.

Another problem Worobec attacked with the Gleeble was occasional surface complaints—cracking on the slab at the slabber or the rougher. Trying to find out at what temperature cracking was occurring, Worobec did a gross ductility test. Then he began using the Suzuki method of continuous casting simulation on the Gleeble.

With this technique, Worobec was able to tell the people in charge of Dofasco's caster what critical temperatures they must avoid when the continuously cast slab is going from the vertical to the horizontal position. Now when Dofasco is going to cast an unknown chemistry, they can produce it in the induction furnace, then simulate continuous casting and hot rolling for that material on the Gleeble.

The Gleeble has also proved useful in optimizing Dofasco's galvanneal lines. Worobec reports, "We had to produce operating windows—not too hot or the coating would powder, and not too cold or the coating won't alloy the steel underneath."

To do that, Worobec worked closely with DSI to develop the strip annealing set-up, including the invention of an improved quench cooling system. The effort has proved highly successful for Dofasco, according to Worobec. "Now, we can tell the annealing people 'keep the process within these parameters and you'll produce good product all the time.' Frequently we run into the problem that the instrumentation on the Gleeble is more precise than that on the production line, and sometimes we use the Gleeble to calibrate on-line instrumentation."

There are additional benefits for Worobec in doing strip annealing testing on the Gleeble. "The sample is a strip two inches wide by a foot long—we can punch out two tensile tests from an annealed sample and measure the physical properties: strength, elongation, hardness, all from one test sample. It's very convenient and efficient, much cheaper than running a trial coil through the mill."

The Gleeble tests also impact the bottom line directly. Using the test results generated by the Gleeble, Dofasco can also realize energy savings by not running the annealing lines too hot. The potential savings from optimizing the line is in the millions of dollars—in saved money on heating costs and in preventing the production of product that would have to be scrapped because it doesn't meet Dofasco's high quality standards.

ISPS Symposium

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- Casting, melting, and solidification processes.
- Thermal and/or mechanical fatigue and other thermal/mechanical processes.
- Semi-solid processing.

Workshop sessions on physical simulation techniques will be conducted and will feature discussion of techniques and methods used for various tests and simulations. Concurrent with the symposium, there will be a meeting of Gleeble users and an opportunity for them to exchange information on techniques, projects, tests, and simulations.

Customer Service

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To help us better serve you when reporting a problem via phone or fax, please provide the following information:

- ❒ A description of the test or simulation you are trying to run.
- ❒ The strain rates or temperatures are you trying to achieve.
- ❒ The mode of mechanical control (stroke, c-strain, etc.)
- ❒ The switch settings of the modules used during the test.
- ❒ Details of specimen geometry, specimen free span, and materials. For example, 10mm round specimen, 20mm free span, 304 stainless steel.
- ❒ A copy of the computer program and plots of the data obtained.
- ❒ A detailed description of the problem.
- ❒ Your Gleeble system serial number.
- ❒ The version number of the Gleeble software you are using.

Your assistance in providing this information when initially reporting a problem will greatly reduce the time required to solve a problem, and therefore will save you time and money. If you have any questions concerning service and technical support, please do not hesitate to contact us at (518) 283-5350 or fax (518) 283-3160.

Come See Us at These Shows!

DSI will exhibit at the Trends in Welding Research Conference, June 5–9, 1995. The conference will be held at the Park Vista Hotel, Gatlinberg, Tennessee.

In addition, you can see us at the ASM/TMS Materials Week, October 30 through November 2, 1995, to be held at the Cleveland Convention Center, Cleveland, Ohio.

ASM INTERNATIONAL ® The Materials Information Society

For information about either of these shows, contact ASM International, Materials Park, Ohio 44073-0002, telephone (216) 338-5151, or fax (216) 338-4634.

DSI will also exhibit at the 5th Metallurgical Industry Expo in Beijing, China. This show will be held April 21 through April 26, 1995. DSI engineers will be available at the show to discuss Gleeble system applications.

For more information about this show, contact China International Exhibition Centre, Beijing, China, telephone +86 (1) 467 8309, or fax +86 (1) 467 6811.

Call for Papers—International Symposium on Physical Simulation

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

- 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 solidifcation 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:

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Paper Submission Schedule:

- Abstracts due — October 1, 1995
- Presentation requirements mailed to authors — November 1995
- Papers due — April 1, 1996
- Proceedings printed and mailed — Fall 1996

Conference proceedings will be published by DSI.

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.

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