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The Gleeble® NEWSLETTER

Summer 2008

Compression Test Adapter Available

The compression test adapter is an option for Gleeble 3500 and 3800 systems that allows researchers to run improved quality compression tests with an existing pocket jaw system.

At present, if you wish to run compression tests on a Gleeble system, you have three options:

1. You can use the existing pocket jaw set and insert small insert adapters designed for running compression tests. For low-speed tests this works well, but has limitations. For example, because the pocket jaws are designed for tensile tests, the alignment and rigidity is not optimized for compression style tests. In addition, if you want to run a compression test and stop at a specific deformation, you will have to compensate for the fact that the hydraulics stop the piston. As a result, there will be a deceleration period that will affect your results.

2. You can use a Hydrawedge®, which is available from DSI as a stand-alone machine or as a Mobile Conversion Unit for the Gleeble. The Hydrawedge is the only commercially available machine that offers the capability to perform high-speed deformation simulations with complete independent control of both strain and strain rate. Through its patented technology, the Hydrawedge delivers test results without strain overshoot or strain rate deceleration, either of which can reduce the validity of the simulation. For multiple-hit compression tests where strain and strain rate are controlled separately

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Gleeble Application Story

The Gleeble at The Technical University of Brandenburg at Cottbus

By Ralf Ossenbrink

The Technical University of Brandenburg at Cottbus (BTU Cottbus) is an internationally recognized, innovation-oriented, technical university for research and teaching. Its areas of concentration are: the environment, energy, materials science, building and construction as well as information and communication technology. The courses of study in the Department of Mechanical Engineering are linked to the main aspects and skills in the corresponding research activities: technologies for automobile and aircraft engines, manufacturing engineering, and light weight construction.

The Gleeble 3500-10/1HS-75 was installed in March 2007 in the laboratory of the Chair of Joining Technology (LFT) to support education and research work in the field. The research profile of the LFT consists of three main directions: joining, testing, and modelling and simulation. One of the current projects in the field is the modification of a traditional welding procedure in cooperation with a regional manufacturer of welding equipment to enhance the applicability of a particular welding process. Other projects with partners from regional industry deal with plasma arc weld surfacing of nickel-based superalloys and repair welding of magnesium alloys using innovative arc welding procedures with reduced heat input. The modelling and simulation activities of the LFT are focused on the prediction of welding distortion, residual stresses, and microstructure in the heat affected zone for different welding processes. In this area we work closely with a supplier for the automotive industry and investigate the microstructure, transformation, and thermomechanical material properties for the numerical simulation of laser beam welding of high strength steels.

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The Gleeble laboratory at the Technical University of Brandenburg at Cottbus. From left, Cecylia Nauroschat, Cord Hantelmann, Prof. Vesselin Michailov, Ralf Ossenbrink.

Recent Gleeble Papers

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Ultra Fine Grain Steels and their Properties

by Y. Weng and H. Dong

Plain low carbon steel, high strength low alloy steel and structural alloy steel are the most widely used three categories of steels, which occupies totally about 70 percent of the total steel consumed. Nowadays, the yield strength of plain low carbon steel is at 200 MPa class, the yield strength of high strength low alloy steel is at 400 MPa class, and the ultimate tensile strength of structural alloy steel is at 800 MPa class. In order to meet the increasing needs from economic and social developments in the future, the research on new generation steels with higher strength and longer duration are now underway in China. The targets are to raise yield strength of plain low carbon steel from 200 MPa class to 400 MPa class, to raise yield strength of high strength low alloy steel from 400 MPa class to 800 MPa class, and to raise ultimate tensile strength of structural alloy steel from 800 MPa class to 1500 MPa class. Bearing this in mind, super cleanness, high homogeneity and ultra fine grain are the three main characteristics of the new generation steels to reach the goal of higher strength and longer duration. It is well known that there exist many mechanisms to strengthen the steel, but the grain refinement is the only method to improve both strength and toughness simultaneously. People have paid great effort in searching the effective method of grain refinement for steels in the long run. And the characteristics of ultra fine grain steels are always attractive to metallurgists. At present, the smallest ferrite grain in plain low carbon steel strips is of 20 μm in size in industry production scale, and the finest ferrite grain in plain low carbon steel rebar is of 30 μm in size. For high strength low alloy steel strips produced in industry, the smallest ferrite grain is of 10 μm in size. The prior austenite grain in structural alloy steels is of 10 μm in size for conventional heat treatment. In order to attain the goal of high strength, grains in plain low carbon steel need be refined to below 5 μm. Grains in high strength low alloy steel should be refined to about 1 μm. And prior austenite grains need to be refined below 5 μm in structural alloy steel. In this paper, the methods for grain refining in the steel will be investigated. The microstructure and mechanical properties of ultra fine grain steels will be described.

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Carbon Distribution Between Matrix, Grain Boundaries and Dislocations in Ultra Low Carbon Bake Hardenable Steels

by A.K. De, B. Soenen, B.C. De Cooman, and S. Vandeputte

The evolution of the carbon distribution between bulk, grain boundaries and dislocations during both the continuous annealing and the strain aging (e.g., paint baking) of ULC BH steels is numerically simulated. The calculations are successfully fitted to strain aging experiments and internal friction measurements. An increase of the grain size together with a higher cooling rate from the annealing temperature significantly increases the bake hardenability of ULC BH steels. This is contrary to the situation in low carbon BH steels due to the presence of the cementite particle distribution between grain boundaries and matrix in the latter steel.

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Microstructure Evolution of a State-of-the-Art Ti-Nb HSLA Steel

by N. Nakata and M. Militzer

High-strength low-alloy (HSLA) steels are an important class of materials in automotive applications, primarily for the development of fuel-efficient, lightweight vehicles. HSLA steels with tensile strengths as high as 780 MPa are currently used for high-strength vehicle components, e.g., wheel discs. The pipeline industry is also experiencing a drive for higher strength steels; linepipe grades with a minimum yield strength of 550 MPa are now state-of-the-art. It can be expected that in the coming decade linepipe steels with a minimum yield strength of 700 MPa will become the standard. Strength levels in the 550–800 MPa range are related to a predominantly acicular ferrite microstructure with grain sizes of 3 μm or below and precipitation hardening which is associated with microalloying elements such as Ti and Nb. Commonly, these steels are controlled rolled in a hot mill. Accelerated cooling on the run-out table is the key processing step for developing the desired fine grained ferrite microstructure as a result of the austenite decomposition. The complexity of this microstructure makes its characterization a challenging task. Thus, the development of microstructural evolution models for hot rolling of these steels is still in its infancy. Austenite-to-ferrite transformation models for low carbon steels have been developed and validated for steels with a polygonal ferrite microstructure including HSLA steels with tensile strengths of 400–500 MPa. A first attempt to extend these approaches to a 550 MPa HSLA-Nb/Ti steel has been proposed by Militzer et al. The transformation requires a significantly higher undercooling to occur in these steels. Thus, it is required to understand the characteristics of transformation for high undercooling and to assess whether the previously proposed models remain applicable in the undercooling range. In the present work, the austenite decomposition of a state-of-the-art Ti-Nb HSLA steel with a tensile strength of 780 MPa has been investigated for run-out table cooling conditions. Torsion tests have been carried out to simulate the entire hot rolling process from reheating to coiling. The austenite decomposition kinetics have been studied in detail with continuous cooling transformation (CCT) test. The effects of initial austenite grain size, cooling rate and retained strain on the austenite decomposition kinetics have been quantified. Based on the experimental investigations, an austenite-to-ferrite transformation model has been proposed for the present steel which also predicts the ferrite grain size. The model has been evaluated by applying it to industrial processing conditions and comparing the predictions with industrially produced microstructures.

First Gleeble System Installed in Russia Equipped with Four MCUs

A Gleeble 3800 has been installed at the Plasticity, Structure and Properties of Metals Laboratory at the St. Petersburg Polytechnical University, St. Petersburg, Russia. The installation is unique in that it is the only Gleeble outside of DSI Headquarters that is equipped with four General Purpose Mobile Conversion Units (MCUs).

The system features 20-ton maximum compression force, 10-ton maximum tension force, 2 meter/sec maximum stroke rate and a high-speed hydraulic servo valve system. Included with the system are the Pocket Jaw, MAXStrain, Hot Torsion, and Hydrawedge MCUs. The result is unprecedented flexibility to perform any test or physical simulation that is possible with a Gleeble.

The purchase of the Gleeble was funded by the Russian federal government with the primary mission of improving education for students. During this year and next, the faculty at St. Petersburg Polytechnical University will be developing programs for teaching students to take full advantage of the Gleeble and the four MCUs for process simulation and optimization, materials characterization, and basic research.

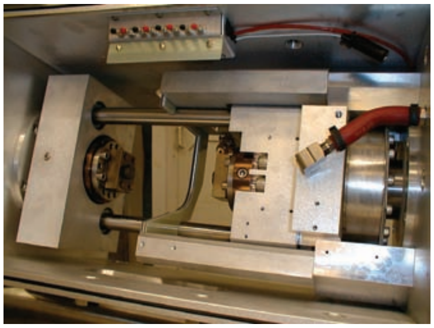
Research with the new Gleeble is also sponsored by Severstal (“North Steel”), a Russian holding company and strategic partner of St. Petersburg Polytechnical University that owns rolling mills, automotive factories, and other industrial facilities in Russia and around the world. Severstal owns a rolling mill in St. Petersburg which is unique because of the 4,500 mm width of the plate processed there. The mill produces steel for pipes for the oil and gas industry.

Working with Severstal, research on the Gleeble at St. Petersburg Polytechnical University will have three key priorities:

- Improvement of steel for pipelines, including increasing the mechanical properties of the steel and decreasing the thickness of the steel so that costs will be lower while the resultant pipes can handle more pressure and flow.
- Optimizing production of auto body steel.
- Development of new base maps for the Hot Strip Mill Model (HSMM) computer software that simulates hot strip rolling mills.

In late July and early August, 2008, Anton Naumov, engineer, and Victor Duranichev, assistant teacher, visited DSI headquarters for two weeks of advanced training in physical simulation and testing using the Gleeble 3800 and four MCUs.

In summer, 2008, two researchers (center) from St. Petersburg Polytechnical University visited DSI Headquarters for two weeks of advanced training. From left, David Ferguson, president of DSI; Daniel McKay, DSI systems engineer; Victor Duranichev, assistant teacher; Anton Naumov, engineer; Todd Bonesteel, DSI director of sales and marketing, and David Jacon, DSI systems engineer.



The Compression Test Adapter is an economical way to get high quality flow-stress data with a single compression hit.

Compression Test

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or synchronously, the Hydrawedge provides superior performance.

3. You can use the Compression Test Adapter in a standard pocket jaw Gleeble. The pocket jaws are removed and the Compression Test Adaptor inserted in their place. It eliminates much of the mechanical compliance of the small inserts used in the pocket jaws and provides improved alignment as well as providing the option for a mechanical stop at a certain deformation. If your goal is to obtain flow-stress data with a single compression hit, the Compression Test Adaptor is an economical way to get high quality results.

For more information about the Compression Test Adapter, contact us here at DSI.

We Want Your Papers

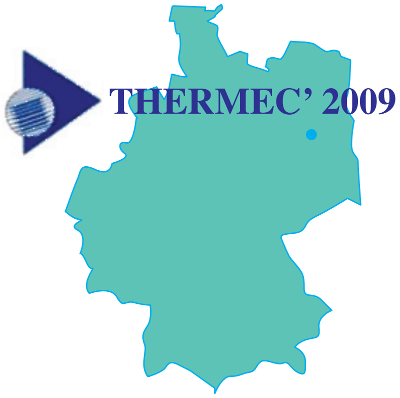
If you’re doing research with a Gleeble physical simulation system and have published or presented papers on your work, we want to hear from you. We would like a copy of your paper so that an abstract can be published in the “Recent Gleeble Papers” section of the Gleeble Newsletter.

Over the years, well over 500 papers have been featured in the Gleeble Newsletter. To make sure your paper is included, mail it to Dynamic Systems Inc., P.O. Box 1234, Route 355, Poestenkill, NY 12140 USA; Fax it to 518 283-3160 or email it to info@gleeble.com.

See Us at the Shows

THERMEC' 2009, August 25–29, 2009, Berlin, Germany

THERMEC' 2009, Sixth International Conference on Processing and Manufacturing of Advanced Materials will be held August 25–29, 2009, in Berlin, Germany. The Conference will cover all aspects of processing, fabrication, structure/property evaluation and applications of both ferrous and non-ferrous materials including hydrogen and fuel cell technologies, metallic glasses, thin films, ecomaterials, nanocrystalline materials, biomaterials and other advanced materials.



The last THERMEC was held in Vancouver, Canada, in 2006 and attracted over 1,250 delegates who presented over 700 papers from 35 countries.

For further information, visit http://thermec.uow.edu.au or contact:

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The Gleeble at The Technical University of Brandenburg at Cottbus

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Within the scope of the Graduate Teaching Program, a team of young researchers want to develop a new generation of aircraft engine parts, especially compressors. The involvement of regional manufacturers of aircraft engines—Rolls-Royce Germany and MTU Aero Engines—ensures application-oriented research. In this context we use the Gleeble 3500 for studying and improving the process to manufacture the compressor. The investigations cover traditional super alloys and innovative γ-TiAl based alloys. The studies include the physical simulation of electron beam welding of the compressor blades with the hub and subsequent heat treatment. The objective of the investigation is to reproduce the rapid thermal cycles due to welding and to characterize the mechanical properties, like hardness, toughness, creep resistance, and strength of the resulting microstructure. For improvement of the process used to forge the compressor blades, we use compression tests to study the influence of temperature and strain rate on flow behavior and microstructure. What we learn about improving the manufacturing technologies will be transferred to the real manufacturing processes.

The numerical simulation of welding processes in order to predict residual stresses and distortion is an important part of our research activities. For accurate predictions we must take into account the influence of the solid-state transformation taking place during certain welding thermal cycles, as well as their influence on the resulting material properties. For this purpose we have developed a complex microstructure model for steels that describes the influence of peak temperature, austenisation time and cooling time on the thermomechanical properties. The calibration of the model requires a broad range of experiments, feasible only with the Gleeble system. In that way, for typical welding thermal cycles, we measure the thermal strains and perform tensile tests during heating and cooling to identify the mechanical behavior. In addition, we study the effects of small loads during phase transformation on the resulting strains, the so called transformation plasticity. Such Gleeble investigations have already been involved in two Ph.D. theses, and the results have been used to minimize distortion during laser beam welding of fuel injectors for combustion engines.

New studies will simulate thermal joining of steels and aluminum alloys. As the microstructure development for steel and Al is based on different mechanisms, we have to integrate specific microstructure models for both materials. The development of the models and their calibration will be done by physical simulation and material testing with the Gleeble 3500.

Another new study, which is planned, concerns the problem of cold cracking during laser beam welding of high strength steels used by our industry partners. Further investigations will be done to develop a new cold cracking test with the Gleeble 3500. The goal is to identify a critical combination of hydrogen content, tensile stresses, and microstructure during and after welding. The resulting parameters should be the basis for a new model to predict cold cracking resistance early in the development of welded structures. This will lead to a significant reduction of time- and cost-consuming experimental welding studies.

Besides the application in industrial research the Gleeble is an important tool for teaching the students at the BTU Cottbus. In practical training courses we exemplify the influence of the thermal effect of welding on the microstructure. The exercises include measuring of thermal strains for different cooling rates, analysis of the temperatures of the phase transformations and summarizing them in Continuous Cooling Time diagrams. The training courses with the Gleeble make it easier for the students to understand the complex contents of the theoretical lectures and prepare them better for the requirements of the regional economy. Furthermore, the LFT takes part in the education of "International Welding Engineers," where the Gleeble supports our training course contents with hands-on experience.

The Gleeble enables the LFT to do education, research and development on a high level. This gives us a better chance to compete successfully with other universities and research institutes. Furthermore, high tech laboratory equipment, like the Gleeble, makes our university and region more attractive to young people as well as young scientists.